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STUDIES IN MILK SECRETION

XII. Transmitting Qualities of Holstein-Friesan Sires for Milk Yield, Butter-Fat Percentage and Butter-Fat

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BULLETIN 301

STUDIES IN MILK SECRETION.

XII. Transmitting Qualities of Holstein-Friesian Sires for Milk Yield, Butter-Fat Percentage and Butter-Fat.[1]

By John W. Gowen and Mildred R. Covell.

SUMMARY

This paper presents an analysis of Holstein-Friesian advanced registry sires to determine their ability to transmit milk yield, butter-fat percentage and butter-fat to their offspring. The numerical measure defining this transmitting ability, is the difference in age corrected yield of the daughter from the age corrected yield of the dam. Tersely expressed the major conclusions may be stated as follows.

The daughters' milk yields show a slightly significant increase over the milk yields of their dams. The daughters' butter-fat percentages are slightly lower than the dams' butter-fat percentages.

Three tables have been formed to show the transmitting power of the sires for milk yield, butter-fat percentage and butter-fat. These tables give the sires' names arranged according to the net increase or decrease of their daughters' yields over the yields of the dams. They present the sire's name, the number of his daughters from tested dams, the net daughter-dam difference in yield and the quartile divisions of the yields for both daughter and dam.

The information is also summarized to show the transmitting ability of the sire to his sons as judged by the production of the son's daughters as compared with the dams of these daughters.

Two major groups of sires are studied for inbreeding and relationship and for the ancestors which their pedigrees contain. The first group of sires increased their daughters' milk yields

[1]Papers from the Biological Laboratory, Maine Agricultural Experiment Station, No. 148.

and butter-fat percentages, the second group decreased their daughters' milk yields and butter-fat percentages. The inbreeding of the two groups does not differ significantly. No significant difference in the relationship shown by the sire and dam exists for either the first or second group of sires. Comparison of the two groups of sires and also a random sample group without any advanced registry offspring show that the ancestor of each group differ only slightly from each other; e. g. there are a large number of common ancestors between each group. These ancestors occur in about the same proportions in each group.

The milch cows in the United States total to nearly 25,000,000 head with a valuation of approximately 1,600,000,000 dollars. If the life of a cow is 10 years this would mean that there would be replaced each year by breeding operations not less than 2,500,000 head of dairy cattle.[2] The heifers in this total depend for their usefulness on their ability to produce milk; the bull's value may be expressed in his ability to transmit high milk yield to his offspring.

The cardinal principle of the dairy cattle breeder today is that "like begets like." In fact if the speeches at farmers' gatherings are followed, if the breeder is questioned or if the literature on cattle breeding is studied intensively, the same phrase always appears transcendent, the one cornerstone of modern dairy cattle breeding. With an industry so important to each and all of us it may be well to inquire into the soundness of this guiding principle. Has it been adequately tested? The answer generally given is that it has. When pressed for evidence the reply practically always refers to some such thing as coat color or possibly type. It evades the point, for what is desired is not whether it will work for coat color but whether it is right for milk yield and butter-fat percentage. In support of this hypothesis, in rare instances, data are cited for these variables, milk yield and butter-fat percentage. The cases selected are unfortunately always ex-

[2]In actual point of fact the turnover in the dairy cattle business is very much larger than this, both because of the fact that the average life of a dairy cow is shorter than 10 years and because of the greater number of births than is herein accounted for. The total, however, as given clearly shows the tremendous size of the dairy cattle breeding industry.

ceptional, for they always refer to the great performers without any adequate analysis of the low producers. The worthlessness of such evidence has been shown in a previous paper, "On the Progeny Performance of Holstein-Friesian Sires,"[3] where a study was made of all year test milk yields of advanced registry Holstein-Friesian sires' daughters. It is proposed in this paper to make a similar study of these sires using a somewhat more adequate measure of the sires' true transmitting ability. This measure has already shown its wide application to simliar problems of another breed.[4] The record commonly stated as the "Daughter-Dam Test," gives in concrete terms a measure of the inheritance for milk yield or butter-fat percentage the bull in question transmits to his daughters when given the average inheritance of their dams upon which to work. Such a measure primarily aims at the germ cells, it is in fact, a measure of the genotype of the bull as distinguished from the phenotype. This measure is further entirely free from any preconceived notions of the mode of inheritance of their milk yield. It is entirely free from personal bias. It simply gives in easily appreciated numerical terms what the bull accomplished, in no way trying to analyze the chain of events which brought about this accomplishment.

Purely aside from the theoretical results the measure furnishes information particularly desired by the breeder, namely, whether the animals which he breeds are transmitting productive qualities to their offspring. Stated in concrete terms, if D_a represents the milk production of a daughter of a given bull and D_m the milk production of the dam of this daughter; then the measure of this bull's transmitting qualities for milk production of this pair would be

$$\text{Sire's transmitting power} = D_a - D_m$$

If the daughter's production is more than the dam's the sign will be plus. The bull is increasing the production of his daughters and consequently, furthering the interests of the breed. If the

[3]Gowen, John W., Covell, Mildred R. Studies in Milk Secretion. IX. On the Performance of the Progeny of Holstein-Friesian Sires.

[4]Pearl, Raymond, Gowen, John W., and Miner, John Rice. 1919. Studies in Milk Secretion. VII. Transmitting Qualities of Jersey Sires for Milk Yield, Butter-Fat Percentage and Butter-Fat. Annual Report of the Maine Agricultural Experiment Station for 1919. pp. 89-204.

daughter's production is less than her dam's the sign will be minus. The bull is, consequently, detrimental to the breed. By the summation of these plus and minus differences with regard to sign, the amount and sign of this summed quantity gives the measure of what he did for all his daughters or averaging this difference gives a measure of what he did for each daughter.

This measure has been applied to those Holstein-Friesian sires, which, up to volume 32 of the advanced register, have 365 day test daughters from 365 day test dams. Specifically stated, the investigation aims to furnish information on

1. The variability of Holstein-Friesian milk yield.
2. The transmitting qualities of Holstein-Friesian advanced registry sires for year milk yield.
3. The transmitting qualities of Holstein-Friesian advanced registry sires for butter-fat percentage.
4. The net change in the yearly production of butter-fat between the daughter's production and mother's production for these same sires.
5. The transmitting qualities of the sire as judged by the production of the daughters of his son in comparison with that of their dam.
6. Pedigree analysis of the different groups of sires to determine the effect of inbreeding, relationship, and specific ancestors.

MATERIAL.

The materials used for this study were the records for year tests of Holstein-Friesian cows contained in volumes 13 to 32 of the advanced register of the Holstein-Friesian Association.[5] The rules under which these tests are carried on are given in each volume of this advanced register. They call for the supervision of each test by an accredited representative of the agricultural experiment station or college of the state within which the test is made. The supervisors are under rules which are quite inclusive, meeting practically every contingency which might arise in the conduction of the test. The aim is, of course, the safeguarding of the accuracy of the records. The precautions taken should make this body of data quite accurate.

[5]Holstein-Friesian Association of America. 1902-1920. Advanced Register Year Book V. 13-32.

The greater part of the records contain the following information; advanced register and herd book numbers, volume of last entry, age at calving, length of record, pounds of milk, per cent of butter-fat and total butter-fat. From the herd book number it is possible to obtain the parents. Should the makeup of the advanced register make it possible it would be of very great advantage to have the parental number added to that record.

Methods.

In this investigation the attempt was made to include every bull having two or more daughters with year records in the advanced register, when the dams of these daughters, also, had year records. The reason for not including those bulls with only one daughter was the great variation which such records would take through the influence of chance alone. This variation is seen in table III to be a very considerable quantitiy when two or more records are considered. It would, of course, be much higher for records based on only one daughter, in fact, becoming so great that little or no reliance could be placed on such a record as a measure of the bull's capacities as a breeder.

Methods of Correcting Records of Milk Production and Butter-Fat Percentage at Any Age to the Expected Record at Standard Age

In a recent paper from this laboratory[6] the variation of Holstein-Friesian milk yield with age, was shown to be distinctly "significant." The relation between butter-fat percentage and age was "not significant." In view of these considerations it was decided that correction of milk records for age should be made and that no correction for age should be made for the butter-fat percentage. The equation describing the relation of milk yield to age is

$y=11351.1+873.67x-32.225x^2+1548.36\ Log\ x$ where y is the mean yearly milk yield and x is the age of the cow.

[6]Gowen, John W. 1920. Studies in Milk Secretion VIII. On the Influence of Age on Milk Yield and Butter-Fat Percentage as Determined from the 365 Day Records of Holstein-Friesian Cattle. Annual Report of the Maine Agricultural Experiment Station for 1920 pp. 185-196.

The production at eight years was chosen for the age to which to correct. The actual maximum mean milk yield comes at 8 years and 5 months, as determined by differentiation of the curve given above. These correction factors were determined for each three months of age. All the records used in this study have been corrected to their expected production at this constant age of 8 years. The manner in which this correction was made may be stated mathematically as a simple proportion.

Corrected milk at standard age : observed milk at a years :: Mean milk at standard age : mean milk at a years.

The rules governing the selection of the cow's records were arbitrarily chosen to include the following items

1. If a cow has one 365 day record that record is used.
2. If a cow has two or more 365 day records the record selected is that nearest 8 years old.
3. The records of cows for less than 365 days are omitted from this study. These records will be analyzed in a later paper when other preparatory data are made available.

When a record is mentioned in this paper it is to be taken for granted that such a record is an age corrected record.

VARIATION OF CORRECTED ADVANCED REGISTRY RECORDS

Some interest is attached to the progress which may have been accomplished in increasing milk yield by one generation's breeding operations. The data necessary to test this progress are given in Table 1.

The mean milk yield for mother and daughter, the standard deviations, coefficients of variation, and quartile limits for these distributions are given in Table 2.

Table 2 shows that the milk yield of the daughters of Holstein-Friesian cows is slightly greater than the milk yield of their dams. The difference between the mean milk yields of the two groups is 773.4 ± 167.3 or the difference is 4.6 times its probable error. Such a difference is probably significant. The cause of this increase is not known, as it is a question whether it is due to better feeding and handling or to an actual accumulation of better hereditary factors for milk yield in the daughters of today in comparison with the dams of yesterday, ascribable to a better perception of the laws of heredity underlying breeding operations.

TABLE 1.

Frequency distributions of expected milk production and butter-fat percentage of Holstein-Friesian Advanced Registry cows, mothers and daughters.

Milk Production Pounds	Frequency		Butter-Fat Percentage	Frequency	
	Daughter	Dam		Daughter	Dam
9000–10000					
10000	3	4	2.500–2.600		
11000	6	5	2.600	4	3
12000	12	10	2.700	6	6
13000	25	29	2.800	7	3
14000	33	30	3.900	15	12
15000	42	57	3.000	41	35
16000	48	33	3.100	59	43
17000	66	48	3.200	72	53
18000	55	55	3.300	86	73
19000	63	38	3.400	87	64
20000	53	37	3.500	67	53
21000	43	30	3.600	58	34
22000	32	30	3.700	43	32
23000	36	19	3.800	14	24
24000	27	13	3.900	18	14
25000	20	10	4.000	15	9
26000	15	12	4.100	7	9
27000	12	5	4.200	5	2
28000	12	6	4.300	6	4
29000	1	4	4.400		4
30000	3	1	4.500–4.600	1	
31000	2	1	Total	611	477
32000	1				
33000–34000	1				
Total	611	477			

TABLE 2.

Physical constants for the expected milk yield and butter-fat percentage of Holstein-Friesian Advanced Registry cows, mothers and daughters.

Character	Mean	Standard Deviation	Coefficient of Variation	Quartile Limits		
				First	Median	Third
Daughter's Milk Yield	19604.7±112.8	4131.9±79.7	21.08±.42	16661±154	19246±141	22289±154
Dam's Milk Yield	18831.2±123.6	4903.6±87.4	21.26±.48	15724±168	18499±155	21392±168
Daughter's Butter fat Per cent	3.440±.008	0.311±.006	9.03±.175	3.229±.012	3.418±.011	3.625±.012
Dam's Butter-fat Per cent	3.450±.010	0.322±.007	9.34±.198	3.233±.014	3.416±.012	3.638±.014

These same daughters are slightly less in the butter-fat percentage contained in their milk than the milk of the dams from

whence they came. The difference is —.010±.013. Such a small difference in view of its probable error is not significant. These figures show that with considerable reservation the daughters are slightly better than their dams in milk yield and approximately the same in their butter-fat test.

The standard deviations for these tables give the necessary information to determine the probable error of the mean gains or losses of any number of pairs of daughters and their dams. It has seemed best to base these calculations on the standard deviations of the general population rather than on the standard deviations of the individual sires as it is believed the probable error obtained will be more nearly its true value. The calculation of this probable error of the mean gains or losses is done by the usual probable error of the difference formula, when the standard deviation of the difference is equal to

$$\sqrt{\sigma_1^2 + \sigma_2^2 - 2r_{12}\,\sigma_1\,\sigma_2} \qquad [7]$$

Where σ_1 is the standard deviation of the daughter's correlated milk production, or butter-fat percentage and σ_2 the standard deviation of the dam's milk production or butter-fat percentage as the case may be. The calculation of the probable error in the net change of the butter-fat can be easily made from the above formula after the standard deviation of the net butter-fat of the daughters and the standard deviation of the net butter-fat of the dams are known. The formula for these constants is approximately

$$M_1M_2\sqrt{V_1^2 + V_2^2 + 2r_{12}\,V_1V_2} \qquad [7]$$

Where M_1 equals the mean milk production, M_2 equals the mean butter-fat percentage, V_1 the coefficient of variation of the milk production and V_2 the coefficient of variation of the butter-fat percentage.

Table 3 gives the probable errors derived by the above formula.

This table shows that little reliance can be placed in the mean gain or loss of the milk production, if the figures are based on

[7] Pearl, Raymond. 1909. The Frequency Constants of a Variable $Z=f(x_1x_2)$. In Biometrika, v. VI, p. 437-438.

only two daughters and their dams, for the error due to chance is likely to be 2744.0 pounds or to be "significant" the difference of such pairs would have to be 8232.0, a difference only rarely found. The error on as many as twenty such pairs is not very great (867.7 pounds). The probable error for the butter-fat percentage on two pairs is so large that only differences over .642 can be considered as more than indicative of a superior bull. For the bull that has as many as twenty pairs much smaller differences are required. The probable errors for the number of pairs for the butter-fat are likewise large for those sires which have only two daughter-dam pairs and relatively much smaller for the sires with as many as twenty pairs.

In the balancing up of the true worth of a bull it is essential that these facts be taken into consideration in weighing the evidence as to his merit.

TABLE 3.

Holstein-Friesian year Records. Probable Errors of differences between mean performances of mothers and daughters.

Number of Pairs	Milk	Butter-Fat Percentage	Butter-Fat
2	2744.0	0.214%	103.06
3	2240.5	.174%	84.15
4	1940.3	.151%	72.87
5	1735.5	.135%	65.18
6	1584.3	.123%	59.50
7	1466.7	.114%	55.09
8	1372.0	.107%	51.53
9	1293.5	.101%	48.58
10	1227.1	.095%	46.09
11	1170.1	.091%	43.95
12	1120.2	.087%	42.07
13	1076.3	.084%	40.42
14	1037.1	.081%	38.95
15	1002.0	.078%	37.63
16	970.1	.075%	36.44
17	941.2	.073%	35.35
18	914.7	.071%	34.35
19	890.3	.069%	33.44
20	867.7	.068%	32.59

Change in the Relative Milk Production or Butter-Fat Percentage of a Bull's Daughters Over That of Their Dams.

As indicated in a previous paper on the progeny performance of Holstein-Friesian sires, it is desirable to have the relative

yields of milk, etc. of a given cow put in terms which will show what that cow is doing in comparison with the rest of the breed. In other words this method gives the cow's production not in pounds but in terms of what the other cows of the breed are doing. To do this the records of all cows, as given in Table 1, were divided into 4 equal parts from lowest to highest. The lines of division are called quartiles. The amount of milk or butter-fat percentage for each of these divisions is given in Table 2. Figures 46 and 47 give the histograms and the quartiles for the mother's and the daughter's milk and for the mother's and the daughter's butter-fat percentage.

The quartiles may be designated as follows, A the amount of milk or butter-fat percentage above the third quartile line; B the amount of milk or butter-fat percentage between the median and the third quartile line; C the amount of milk or the butter-fat percentage between the first quartile line and the median; D the amount of milk or butter-fat percentage below the first quartile line. In this way the change in the milk production or butter-fat percentage between any dam and her daughter may be expressed by two letters. For instance, a record of the relative milk production AC means that the dam's milk production is over 21392 pounds and the daughter's milk production between 16661 and 19246 pounds. A butter-fat percentage record DB means that the mother's butter-fat percentage is below 3.233 per cent and the daughter's butter-fat percentage between 3.418 per cent and 3.625 per cent. In recording a bull with two or more daughters it seems best to put these pairs on the basis of one hundred.

Thus, if a bull with two tested daughters out of tested dams, has one dam in respect to milk production in class A and her daughter in class B, the pair will be recorded as AB; if he has the other dam in class C and her daughter in class A the pair will be recorded as CA. The complete record for the bull will be 50AB+50CA and the number of pairs on which this record is based will be two. The extension of this method allows the recording of any number of pairs. In this manner it is possible to always know the number of daughters on which a bull's record is based and where in the general population of daughters these daughters' records lie in comparison with the place in the general population occupied by the records of their dams.

FIG. 46. Histograms showing the frequency distributions of corrected milk production for Holstein-Friesian advanced registry daughters and their dams' (365 day) record. The quartile lines divide these distributions into the four equal areas which are used to denote the relative place for the yield of the cow in the breed.

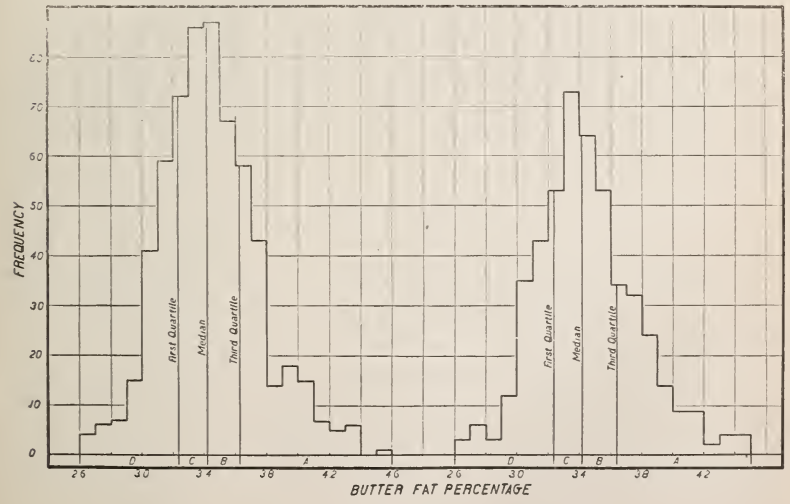

FIG. 47. Histograms showing the frequency distribution of corrected Butter-Fat percentage for Holstein-Friesian advanced registry daughters and their dams. (365 day record.) The quartile lines divide these distributions into the four equal areas which are used to denote the relative place for the yield of the cow in the breed.

A number of points by which a superior sire may be distinguished from an inferior sire will no doubt suggest themselves to the reader. When approached from the point of view of milk yield these points are narrowed considerably. If a sire increases the milk yield of his daughters over that of their dams from which they came, then, that sire is exercising a beneficial effect on the breed. If the sire, also, increases the butter-fat percentage of his daughters over that of their dams he is doubly benefiting the breed. Such a sire would appear to be deserving of preeminence. These sires are designated as 'superior sires' in this paper. In the second group are placed those bulls whose daughters were inferior to their dams in both milk yield and butter-fat percentage. Since, in all probability, the first set were a great boon to the breed and the second set a distinct drawback to the breed's progress it seems of objective value to study these two groups carefully in the hope of throwing some light on the reasons for this difference in the bulls' daughters.

In this connection it is well to consider one other item, e. g. the character of the cows to which the bull is bred. Thus, it is quite probable that a bull bred to cows similar to Tilly Alcartra, in their producing abilities, would be less likely to raise the production of these cows' offspring than if the same bull is bred to cows of the 10,000 pound class. The data on the relative yields of daughter and dam are consequently desirable. This information is given in conjunction with the tables on milk yield and butter-fat percentage.

PEDIGREE METHODS.

Pedigree studies have been made for each of the above group of sires. The methods used in pedigree analysis have been given in the previous paper[8] and need not be repeated here.

Besides these data on inbreeding, these pedigrees have been analyzed for the individual animals contained therein. From the old saying that, "like begets like" it should follow that the ancestors within the pedigree of superior sires should themselves be

[8]Gowen, John W. and Covell, Mildred R. Studies on Milk Secretion. On the Performance of the Progeny of Holstein-Friesian Sires.

worthy animals. If a pedigree study of a group of such superior sires is made, the animals most repeated in a given generation should be the best animals for they have the greatest opportunity to transmit high production to their progeny which are known to carry high production. Some insight should be gained, as to the worth of a given animal by such a study even, though, the animal may not have any other obtainable record. This is especially true in connection with this study, since the pedigrees of the sires which did not transmit high production to their daughters are also known and a comparison may be made of the individuals repeated in the superior sires' pedigrees with those repeated in the inferior sires' pedigrees. To further clinch the point a pedigree study was made of bulls which are known to have no advanced registry daughters. The data for these comparisons are so tabulated as to show the pedigree group, sex, whether the appearance was on the sire's or dam's side of the pedigree and the generation in which the appearance took place.

The Transmitting Qualities of Holstein-Friesian Sires for Milk Production.

In Table 4 is given all Holstein-Friesian advanced registry sires with two or more tested daughters coming from tested dams. These bulls are arranged according to the number of pounds of milk that their daughters' yearly production was greater, than their dams' yearly production. This information is given in the fifth column of the table. These bulls are given a number (shown in the first column) running from the bull producing the greatest average net increase in his daughter's milk production, Ormsby Korndyke Lad, to the bull producing the greatest average net decrease in his daughter's milk production, Romeo Aaggie Acme of Riverside. In the second column is given the bull's name. In the third column is given the registry number. The fourth column contains the number of daughter-dam pairs on which the average net change of milk production is based. The last column marks the quartile changes (records the relative position of the milk production of the dam and daughter). The dam's milk production is recorded first as A, the highest production; B, the next highest group; C, the next to the lowest milk producing group and D the lowest milk producing group. The daughter's milk production is recorded after the dam's, the letters having

the same significance. The distribution and limits for these groups are shown in Table 1, figure 46. The coefficient in front of the letters gives the numbers in each group on the basis of 100 for the total.

Thus, the record for Ormsby Korndyke Lad shows that all the recorded daughters of his get were in the A class; 50 per cent or one-half of them were out of A class dams and 50 per cent were out of D class dams. The coefficients therefore represent the percentages of the different kinds of daughters which a given bull got from different classes of dams.

The information on the transmitting qualities of Holstein-Friesian sires for milk production above described is given in Table 4.

TABLE 4.

Holstein-Friesian sires in order of the net change in milk yield of their daughters over the milk yield of the dams of these daughters.

No.	Name of Bull	Registry No.	No. of Pairs	Net Change Lbs.	Quartile Changes
1	Ormsby Korndyke Lad	102469	2	+7637.5	50AA+50DA
2	Emblagaard Tritomia Homestead	62924	5	+6716.4	20AA+20CB+20CC +40DA
3	King Segis Pontiac Count	93909	2	+6388.0	50AA+50BA
4	Colantha Johanna Champion	45674	2	+6079.0	50AA+50DA
5	Hygeia Veeman Butter Boy	43697	2	+5308.5	100DD
6	Johan Woodcrest Lad	52145	3	+5140.0	67DB+33DC
7	King Pontiac Champion	53418	14	+4862.1	7AB+14BA+14BB +21CA+14CB+ 14DA+14DC
8	Sir Johanna DeKol	25467	4	+4755.8	25BB+25DA+50DC
9	Aaggie Cornucopia Johanna Lad Jr.	36974	2	+4544.0	50BA+50CA
10	Sir Hengerveld Model Johanna	40338	6	+4489.0	33CA+17CB+33CC 17DB
11	Masterpiece	84099	2	+3791.5	50AA+50BA
12	Sir Korndyke Hengerveld De Kol	41266	6	+3665.7	17CA+17CD+17DA +17DC+33DD
13	Johanna Colantha's Lad	28296	2	+3595.0	50BB+50DB
14	King Beauty Pietertje De Kol	50758	2	+3580.0	50BA+50BC
15	Johanna Colantha Sarcastic Lad	38402	5	+3486.6	40BA+20BB+20CA +20CB
16	Alcartra Polkadot Corrector	30624	2	+3420.5	50CB+50DC
17	Sir Ormsby Skylark	47010	2	+3417.0	50BA+50CB
18	Aaggie Clothilde Bawn De Kol	33207	2	+3386.5	50DC+50DD
19	Woodcrest Tehee	74219	10	+3357.6	10AA+10AB+20BA +10BB+10CB+ 10DA+10DB+10DC +10DD
20	Sir Cornucopia Prince	48663	6	+3291.0	17AC+17CB+17CD +33DA+17DD
21	King Segis Hengerveld Vale	60344	5	+3176.4	20BB+20CA+20CB +20CC+20DC

Holstein-Friesian sires in order of the net change in milk yield of their daughters over the milk yield of the dams of these daughters.—Continued.

No.	Name of Bull	Registry No.	No. of Pairs	Net Change Lbs.	Quartile Changes
22	Segis Pontiac De Kol Burke	97472	5	+3008.6	40AA+20BA+20BB +20DA
23	Butter Boy Sir Mechthilde	37392	2	+2949.0	100BA
24	Paul Frenesta De Kol	41206	6	+2744.0	33BB+17DA+17DC +33DD
25	Sir Korndyke Hengerveld Canary	53825	2	+2643.0	100DD
26	Virginia Korndyke Butter Boy	128445	2	+2583.5	50BB+50DB
27	Quirinus Cornucopia	60751	2	+2441.5	50AA+50AB
28	Sir Johanna Piebe	53257	10	+2338.4	10AA+50BA+20BB +20BC
29	Korndyke Netherland Wayne De Kol	47306	2	+2285.5	50BA+50BD
30	Dutchland Colantha Sir Inka	50999	4	+2249.7	25AA+25BA+25BC +25CB
31	Sir Pietertje Lass De Kol	94292	5	+2061.6	40BB+20CB+20DC +20DD
32	Greenwood Johanna Lyons	62049	2	+2057.0	50BC+50DB
33	Sir Johanna Fayne	42147	2	+2049.5	50BB+50DC
34	Pietertje Hengerveld Sir Korndyke	60966	5	+2040.8	60AA+20BA+20BC
35	Homestead Girl De Kol Sarcastic Lad	32558	4	+1995.5	50AA+25AB+25BA
36	Prince Gelsche Walker	81663	5	+1865.0	20AA+20AB+40BA +20CC
37	King Pietertje Cloverdale	69686	3	+1817.0	100AA
38	King of the Pontiacs	39037	3	+1789.7	33BA+67BB
39	Spring Farm King Pontiac 8th	114319	3	+1744.4	33CC+67DC
40	White Segis De Kol	78027	2	+1709.0	100AA
41	Star Farm Johanna Lad	45224	8	+1578.5	13AC+13BC+25DB +13DC+38DD
42	Prince Pietertje Beryl	46977	2	+1509.0	50AA+50CC
43	Sir Walker Segis	50672	10	+1458.3	20BB+10BC+10BD +10CA+20CC+ 20DB+10DD
44	King Ormsby Parthenea	81630	3	+1445.0	67BB+33DC
45	Dawning Johanna Burke De Kol	84472	2	+1196.0	50CC+50DD
46	Spring Farm King Pontiac 6th	103899	2	+1002.0	100AA
47	Canary Paul	48328	3	+ 999.9	33CC+33CD+33DB
48	Small Hopes Korndyke De Kol	32260	2	+ 979.5	100DD
49	Johanna Rue 2d's Paul De Kol	21724	4	+ 975.2	100DD
50	Gem Pietertje Paul De Kol 3d	44658	5	+ 900.8	20BB+20CD+20DB +20DC+20DD
51	King Mead of Riverside	50290	6	+ 871.5	33AA+17BA+17CC +17CD+17DA
52	Sir Carlotta Pontiac Cronus	45502	4	+ 835.2	25BB+75DD
53	Prince Leo Aaltje	61435	3	+ 591.7	33BB+33BC+33CC
54	Duke Segis Inka Korndyke	49722	2	+ 538.0	100DD
55	Johanna De Kol's Lad	26938	7	+ 521.3	14BC+14BD+29CD +29DC+14DD
56	Hartog Paul Burke	49910	3	+ 520.0	33DC+67DD
57	Aaggie Cornucopia Pauline Count 13	44293	4	+ 448.0	50BB+25CC+25CD
58	Korndyke Queen De Kol's Prince	26025	5	+ 434.6	40AC+20BA+20BB +20CA
59	Sir Pietertje Ormsby Mercedes	44931	12	+ 403.3	50AA+17AC+8BA+ 8BB+8DC+8DD
60	Sir Piebe Aaggie Hengerveld	32492	5	+ 394.0	20AA+20BC+20BD +20CB+20CC
61	North Star Longfield Sir Beets	97403	2	+ 317.0	50AC+50DB
62	King Champion Victoria	68544	5	+ 288.0	20BC+20CB+20CD +40DD
63	Sarcastic Lad	23971	5	+ 280.4	20CD+20DC+60DD
64	Knight Errant	39566	2	+ 89.5	50BC+50CB
65	Sir Winana Beets Segis	52927	2	+ 79.0	50CC+50DD
66	Missouri Chief Josephine Lad	70857	3	— 27.3	33AB+33BA+33BD

Holstein-Friesian sires in order of the net change in milk yield of their daughters over the milk yield of the dams of these daughters.—Concluded.

No.	Name of Bull	Registry No.	No. of Pairs	Net Change Lbs.	Quartile Changes
67	Woodcrest Gordon Fayne	97208	2	— 80.0	50CC+50DD
68	Mutual Piebe De Kol	44554	4	— 251.3	25AC+25CB+50CC
69	Mooie Oak De Kol 2d	60278	2	— 270.5	50BD+50DC
70	Colantha Johanna Lad	32481	2	— 279.0	100AA
71	Kalmuck Skylark Johanna	48832	2	— 332.0	50CD+50DD
72	Aralia De Kol Pontiac Segis	112077	2	— 369.0	50AB+50BB
73	Johanna Clothilde 3d's Clyde	30550	2	— 370.5	100CD
74	Sir Johanna Bonheur Fayne	45671	6	— 383.3	17AC+17BA+17BB +33BC+17CC
75	Sir Homestead Posch De Kol	37314	7	— 602.5	14BB+14BC+29CD +43DD
76	Sir Musser Clyde De Kol	40368	2	— 674.5	50CC+50CD
77	Pontiac Aaggie Korndyke	38291	2	— 700.5	100AA
78	King Oak Grove	42235	2	— 732.5	50CC+50CD
79	Sir Concordia Korndyke	75912	2	— 770.0	100AA
80	King Hengerveld Pondyke	47843	6	— 779.5	50CD+50DD
81	Maplecrest Butter Boy De Kol	94156	2	— 809.5	100BB
82	Pabst Pontiac Champion	105106	2	— 861.0	100BB
83	Piersma Albina Segis Lad	75361	2	— 867.5	100DD
84	Johana De Colantha Champion	60574	13	—1081.9	8AC+8AD+8BA+ 23BB+15BC+ 8CB+23CC+8CD
85	Prince Alcartra Korndyke	88318	2	—1114.0	50AB+50DC
86	Pietje 22d's Woodcrest Lad	39849	2	—1120.5	50AC+50CC
87	Sir Hengerveld De Kol Ormsby	31211	2	—1122.0	50BB+50BD
88	Earl Korndyke De Kol	24954	2	—1306.0	100DD
89	Dutchland Sir Pietertje Hengerveld	48696	2	—1508.5	100AA
90	Sir Johanna Aaggie Posch	38401	5	—1655.2	20AB+20BA+40BC +20BD
91	King Pontiac Ruby Burke	58041	2	—1728.0	50AC+50BB
92	Woodcrest Pietje	35469	2	—1728.5	50AC+50BB
93	Prince Ormsby Mercedes De Kol	47008	3	—1827.3	33AB+33BB+33DC
94	Sir College Cornucopia	59755	2	—1904.5	50BD+50DD
95	Sir Johanna Aaggie Posch 4th	72013	2	—2022.0	50AA+50AC
96	Paul Cornucopia Mercedes Aaggie	94884	4	—2085.8	50BD+25DC+25DD
97	King Pontiac Dione	82505	2	—2321.0	50AD+50DD
98	Juliana King of Riverside	38446	3	—2351.3	67AA+33CB
99	Sir Korndyke Hengerveld De Kol 36th	85968	3	—2975.3	67AB+33BB
100	Canary Mercedes Paul	29600	2	—3053.5	50AB+50BB
101	Lakeside Model Alban	71013	2	—3209.5	100BC
102	Oak De Kol 2d Homestead Fobes	65750	2	—3246.0	50AB+50BD
103	Pietje 22d Son	58314	2	—3467.5	50AC+50CD
104	Ladoga King Veeman De Kol	43496	2	—3567.5	100AB
105	Rag Apple Korndyke De Kol	67211	2	—3831.0	50AD+50CC
106	Sir Segis Mutual Walker	80916	2	—3861.0	50CD+50DD
107	Alma Prince Jewel	32731	2	—3908.5	100BD
108	Sir Aaggie Cornucopia Segis	76665	2	—4533.5	50BD+50CC
109	Maple Crest Pontiac Hartog	62178	3	—5624.3	33AA+33AB+33CB
110	Leland Sarcastic	42451	2	—7443.0	50AB+50AD
111	Romeo Aaggie Acme of Riverside	32422	2	—9962.5	50AB+50AD

Table 4 shows that there are 111 bulls with two or more 365 day test daughters from 365 day test dams in the Holstein-Friesian advanced register. Of these 111 bulls 65 or slightly more than one-half increased the milk yield of their daughters over that of the dams of these daughters. This fact shows some-

thing of the condition which exists in the Holstein-Friesian breed. Should it be desired to go out and pick a bull for breeding to advanced registry cows it would be practically an even bet that the choice would make his daughters poorer producers than their dams even though he had advanced registry cows to which to mate.

The sire which increased the production to the greatest amount was Ormsby Korndyke Lad. Only two records are available for study, however. Under these circumstances the record of the second sire, Emblagaard Tritomia Homestead, would be considered as more significant as he had 5 daughters. These daughters were from A class, C class and D class dams. The record of the A class dams was maintained by their daughters; one of the C class dams had her daughter raised to the B class, the other daughter from the C class dams was maintained in the C class; the two daughters from D class dams were raised to the A class.

For similar reasons the record of the sire King Pontiac Champion should be given a place nearly on a par with that of the two leaders because of the fact that he had 14 daughters on which his record is based. The study of Table 4 in conjunction with Table 3 is consequently essential. If a record greater than 3 times the probable error be considered significant, it cannot be argued that more than two sires significantly increased the milk yield of their daughters over that of their dams. These sires are Emblagaard Tritomia Homestead and King Pontiac Champion. If, however, it be considered that a difference of 2 times the probable error has sufficient meaning to deserve investigation it follows that the sires given in Table 5 have daughters with suggestively higher records than their dams.

From similar reasoning there is only one sire who lowered the record of his daughters more than 3 times the probable error of this record. The sires who lowered their daughters' record 2 times the probable error are given in Table 5 where data on the inbreeding occurring in the sires' pedigrees are also given.

Table 5 shows there are 12 sires who increased the milk yield of their daughters over that of their dams to the extent of at least 2 times the probable error of this increase. There are only three sires that decrease the milk yield to this amount. Considered in comparison with the total number of 111 sires 12

seem a disappointing number of sires to have increased their daughters' milk yield to this extent. Considered from the view point of those which decrease their daughters' milk yield the ratio of 12 to 3 appears quite satisfactory.

The pedigree of Ormsby Korndyke Lad, the leader, in increasing the milk yield of his daughter is given below.

Pedigree of Ormsby Korndyke Lad 102469

Maine Agr. Exp. Sta.—Standard Pedigree Blank

Sheet No. +	♂	No. 41266 ♂ Sir Korndyke Hengerveld De Kol	No. 23102 ♂ Hengerveld De Kol	No. 21366 ♂ De Kol 2d's Butter Boy	
				No. 29237 ♀ Magadora	
			No. 65765 ♀ Pontiac Darkeness	No. 25982 ♂ Pontiac Korndyke	
				No. 40182 ♀ Inka Darkness 2d's Queen	
Sex ♂	No. 53822 King Korndyke Hengerveld Ormsby	No. 78051 ♀ Pietertje Maid Ormsby	No. 31212 ♂ Sir Ormsby Hengerveld De Kol	No. 23300 ♂ Gem Pietertje Hengerveld Paul De Kol	
				No. 35439 ♀ Duchess Ormsby 2d	
			No. 53646 ♀ Pietertje Maid of Grouw 3d	No. 23366 ♂ De Kol 2d's Paul De Kol No. 2	
				No. 42832 ♀ Pietertje Maid of Grouw	
No. 102469 Ormsby Korndyke Lad	♀	No. 36219 ♂ Beryl Posch	No. 30154 ♂ Alta Posch's Son	No. 28864 ♂ Worthemall Sir Pietertje	
				No. 54867 ♀ Alta Posch	
			No. 60715 ♀ Lady Beryl Wayne	No. 22909 ♂ Pauline Paul 2d's Count	
				No. 49985 ♀ Beryl Pauline De Kol	
	No. 87900 Polly Posch	No. 57996 ♀ Polvalba 2d	No. 22163 ♂ Sir Pauline De Kol	No. 20579 ♂ Pauline Paul 2d's Colanthus	
				No. 6324 ♀ De Kol 2d's Queen	
			No.. 41174 ♀ Polvalba	No. 19174 ♂ Paragon Netherland Alban	
				No. 16741 ♀ Polly Pharoah	

There are some points of interest concerning these sires which increase their daughters' milk yield. Ormsby Korndyke Lad's[9] daughters are high producers as well as producing considerably over their dams. Emblagaard Tritomia Homestead's daughters were not very exceptional. They were out of rather low producing dams, however. King Segis Pontiac Count's and Colantha Johanna Champion's daughters were quite exceptional producers. Hygeia Veeman Butter Boy, a bull, which nearly got

[9]Gowen, John W. Studies in Milk Secretion. IX On the Performance of the Progeny of Holstein-Friesian Sires.

into this list had daughters which were quite low producers but which were out of very low producing dams. Johan Woodcrest Lad's daughters from tested dams were considerably better producers than were the rest of his tested daughters. Those tested were, on the whole from low producing cows. The daughters of King Pontiac Champion were rather high producing. Sir Johanna De Kol was bred to advanced registry cows with mediocre records. His daughters from these cows were fair producers.

Romeo Aaggie Acme of Riverside was bred to very high producing dams. His daughters' milk yield was only average. Leland Sarcastic and Maplecrest Pontiac Hartog were also bred to high producing cows with a somewhat lower drop in the resulting milk yields of his daughters.

These two lists of sires contained in Table 5 are the extremes for the transmission of milk yield, one representing the most significant increase in yield, the other the most significant decrease. The groups are significantly different. The groups, especially those for the sires decreasing the milk yield of their daughters, are small in numbers. Such being the case ,the constants determined for them will be subject to considerable error from random sampling. The inbreeding and relationship for each group is given in Table 5.

Table 5 shows that there is no significant relation between milk yield and the inbreeding or relationship which occurs in the sires' pedigrees of the two groups.

These pedigrees were also examined to determine if the ancestors were differentiated or if ancestors occurred as frequently in one group as in the other. In this comparison it must be constantly kept in mind that the number of pedigrees in either group is small. Such being the case, the conclusions indicated by the data should be considered as tentative, serving rather as a *guide* than as a *rule* for any breeding operations.

The bulls occurring 4 or more times in the pedigrees of the sires which increased their daughters' production were Paul De Kol (6-4), Aaggie Cornelia 5th's Clothilde Imperial (4-4), Hengerveld De Kol (5-1), Sarcastic Lad (4-1), Maurice Bonheur (3-2), De Kol 2d's Paul De Kol (4-1), Aaltje Salo 3d's Tritomia Netherland (2-2), Paul Mutual De Kol (1-3), De Kol 2d's Butter-Boy (4-0), Pontiac Korndyke (2-2), Manor Josephine De Kol (2-2), Milla's Pietertje Netherland (2-2), Willem III, Clothilde 4th's Imperial (1-3).

TABLE 5.

Inbreeding and relationship existing in the four generation pedigrees of sires increasing or decreasing the milk yield of their daughters over that of their dams.

Sires increasing the milk yields (group 1)

No.	Name	Reg. No.	Z	Z_2	Z_3	ZT_3	K_2	K_3	K_4
1	Ormsby Korndyke Lad	102469	0	0	0	0	0	0	0
2	Emblagaard Tritomia Homestead	62924	0	0	0	0	0	0	0
3	King Segis Pontiac Count	93909	0	12.5	18.8	14.7	0	25.0	37.5
4	Colantha Johanna Champion	45674	0	0	12.5	5.9	0	0	0
5	Johan Woodcrest Lad	52145	0	0	0	0	0	0	0
6	King Pontiac Champion	53418	0	0	0	0	0	0	0
7	Sir Johanna De Kol	25467	25.0	25.0	25.0	50.0	50.0	50.0	50.0
8	Sir Hengerveld Model Johanna	40338	0	0	0	0	0	0	0
9	Sir Korndyke Hengerveld De Kol	41266	0	0	12.5	5.9	0	0	25.0
10	Johanna Colantha Sarcastic Lad	38492	0	0	6.3	3.0	0	0	0
11	Woodcrest Tehee	74219	0	12.5	12.5	10.0	0	25.0	25.0
12	Sir Cornucopia Prince	48663	0	0	0	0	0	0	0
	Mean		2.1	4.2	7.6	7.5	4.2	8.2	11.5

Sires decreasing the milk yields (group 2)

1	Romeo Aaggie Acme of Riverside	32422	0	0	18.8	8.8	0	0	0
2	Leland Sarcastic	42451	0	0	0	0	0	0	0
3	Maple Crest Pontiac Hartog	62178	0	12.5	12.5	10.0	0	25.0	25.0
	Mean		0	4.1	10.4	6.2	0	8.3	8.3

The females occurring 3 or more times in this same group of pedigrees are De Kol 2d (5-3), Belle Sarcastic (4-1), Belle Korndyke (2-2), Magadora (4-0), De Kol (2-1), Colantha 4th (1-2), Johanna Rue (0-3), De Kol 2d's Queen (0-3), Colantha (1-2), Aaggie Cornelia 5th (1-2), Mutual Friend 2d (1-2). The figures in the parenthesis give first the number of appearances on the sire's side of the pedigree and second the number of appearances on the dam's side of the pedigree. It will be noted that the arrangement of the animals in these 2 lists is that of the number of times each animal appears.

The males occurring 2 or more times in the pedigrees of the 3 bulls which decrease the production of their daughters are *Paul De Kol* (1-1), *Aaltje Salo 3d's Tritomia Netherland (1-1)*, Sir Newton of Aaggie 5th (0-2). The females which occur 2 or more times are *De Kol 2d* (2-0), Almeda Luecke (1-1), Almeda Luecke 2d (1-1), Bracelet (0-2).

It will be noted that there is a much fewer number of animals in the second group than appear in the first group. This is due, of course, to the difference in the number of sires pedigreed.

Three of the animals in the second group are *in italics*. These animals also appear in the pedigrees of the first group of sires. They are in fact prominent in the first group having a relatively large number of appearances. Such being the case, it is clear that the appearance of certain famous animals in the pedigree of a bull is no guarantee of what his daughter-dam test will be. It now remains to be seen if the appearances of the same animals are sufficiently frequent in each group to make the appearance of any such animal within the pedigree an unreliable measure of this sire's worth. Unfortunately the number of pedigrees is too small to make such a comparison of more than very doubtful value. It is consequently considered better to await the discussion of the groups of sires which increase the milk yield and butter-fat percentage of their daughters versus those which decrease the milk yield and butter-fat percentage, where this point may be more adequately treated.

The Transmitting Qualities of Holstein-Friesian Sires for Butter-Fat Percentage

The arrangement of Table 6 containing this information is entirely similar to that of Table 4. In this table is given all advanced registry bulls which have two or more daughters tested for year butter-fat percentage from dams of known year butter-fat percentage. These bulls are arranged in accordance with the butter-fat percentage by which the daughter's milk was in excess or defect of the butter-fat percentage of the dam's milk. Symbolically expressed,

Sire's Transmitting Qualities for Butter-Fat Percentage = Daughter's Butter-Fat Percentage—Dam's Butter-Fat Percentage.

This information is given in the fifth column of the table. The bulls, as in the previous table, are numbered in accordance with the position they occupy in the table. This number is given in the first column. The second and third columns are given over to the names and herd book numbers of the different bulls. In the fourth column are the numbers of daughter-dam pairs on

which the progeny test rest. The fifth column gives the net change in the butter-fat percentage as above discussed. The sixth column gives the quartile in which the given daughter's butter-fat percentage and the dam's butter-fat percentage occur. Each daughter-dam pair is described by two letters. The quartiles are shown in figure 47 for the daughter's butter-fat percentage and for the dam's butter-fat percentage. Table 1 gives the frequency distribution and Table 2 gives the limits of each quartile. The quartiles are designated as A, the highest butter-fat percentage group; B, the next highest butter-fat percentage group; C, the third highest butter-fat percentage group; and D, the lowest butter-fat percentage group. As the name signifies each quartile contains one-fourth the total number of individuals in the whole population. The letter consequently gives the place for their respective populations in which the dam's or daughter's butter-fat percentage falls. The letters together give the relation of the dam's position to that of the daughters. Thus, AC tell us (the dam's letter is always placed first) that the dam's butter-fat percentage is in the highest group or above 3.638 per cent and the daughter's butter-fat percentage is the third group or between 3.229 and 3.418 per cent.

The coefficients in front of the letters signify the percentage that a given kind of daughter-dam pair was of the total number of pairs into which the bull entered. This coefficient is multiplied by 100 to have the coefficient in whole numbers. With this arrangement it is possible to tell to what kind of dams a bull was mated and what his daughters from these matings did.

There are in this list 111 bulls which have two or more daughters from tested dams. Of these bulls 52 raised the butter-fat percentage of their daughters over that of their dams. The number of bulls which improved the breed were somewhat less than half of those in use. In this list the greatest number of daughter-dam pairs for any given bull is 14 for King Pontiac Champion. Close seconds to him were Johanna De Colantha Champion and Sir Pietertje Ormsby Mercedes with 13 and 12 pairs, respectively.

The bull which caused his daughters to have the highest butter-fat percentage over that of the butter-fat percentage of their dams, was Kalmuck Skylark Johanna. This bull raised the butter-fat test of his daughters 0.665 per cent of butter-fat. Both

TABLE 6.

Holstein-Friesian sires in order of the net change in butter-fat percentage of their daughters over the butter-fat percentage of the dams of these daughters.

No.	Name of Bull	Registry No.	No. of Pairs	Net Change %	Quartile Changes
1	Kalmuck Skylark Johanna	48832	2	+0.665	100CA
2	Romeo Aaggie Acme of Riverside	32422	2	+0.650	50CA+50DA
3	Juliana King of Riverside	38446	3	+0.637	33CA+33CB+33DB
4	Paul Cornucopia Mercedes Aaggie	94884	4	+0.575	25BA+50DA+25DB
5	Canary Mercedes Paul	29600	2	+0.560	50CA+50DB
6	Prince Ormsby Mercedes De Kol	47008	3	+0.553	67BA+33DB
7	Maple Crest Pontiac Hartog	62178	3	+0.530	33AA+33BA+33CA
8	Pontiac Aaggie Korndyke	38291	2	+0.465	100AA
9	King Oak Grove	42235	2	+0.425	50BA+50DC
10	Prince Pietertje Beryl	46977	2	+0.420	50DB+50DC
11	Johan Woodcrest Lad	52145	3	+0.413	33DA+33DB+33DC
12	Alcartra Polkadot Corrector	30624	2	+0.405	50DB+50DC
13	Dutchland Sir Pietertje Hengerveld	48696	2	+0.400	50DA+50DD
14	Mooie Oak De Kol 2d	60278	2	+0.395	50BA+50DC
15	Korndyke Netherland Wayne De Kol	47306	2	+0.360	50DA+50DD
16	King Pietertje Cloverdale	69686	3	+0.354	33DB+33DC+33DD
17	Greenwood Johanna Lyons	62049	2	+0.340	50AA+50CA
18	Homestead Girl De Kol Sarcastic Lad	32558	4	+0.338	25DC+75DB
19	Canary Paul	48328	3	+0.306	33BA+33BB+33CA
20	King Mead of Riverside	59290	6	+0.304	33AA+17BA+17BB +17BC+17CA
21	Gem Pietertje Paul De Kol 3d	44658	5	+0.293	20BA+40BB+20CA +20DC
22	Pietje 22d's Woodcrest Lad	39849	2	+0.290	50CA+50DB
23	Sir Aaggie Cornucopia Segis	76665	2	+0.269	50CA+50DC
24	Sir Korndyke Hengerveld De Kol	41266	6	+0.259	33AA+17DA+17DB 33DC
25	Sir Johanna Aaggie Posch	38491	5	+0.258	20AA+20BA+40CA +20CC
26	Sir Homestead Posch De Kol	37314	7	+0.236	14AA+14CC+29DA +14DB+29DD
27	Sir Winana Beets Segis	52927	2	+0.229	50BD+50CA
28	Aaggie Cornucopia Pauline Count 13th	44293	4	+0.210	25AA+25AB+50CA
29	Hartog Paul Burke	49910	3	+0.207	33CA+33CB+33CC
30	Rag Apple Korndyke De Kol	67211	2	+0.205	50CA+50CC
31	Downing Johanna Burke De Kol	84472	2	+0.200	50BC+50CA
32	Knight Errant	39566	2	+0.145	50AB+50CA
33	Pietertje Hengerveld Sir Korndyke	60966	5	+0.116	20AB+20CA+20DB +20DC+20DD
34	Sir Segis Mutual Walker	80916	2	+0.115	50BB+50CB
35	King of the Pontiacs	39037	3	+0.113	67AA+33DB
36	Woodcrest Pietje	35469	2	+0.110	50BA+50DC
37	Johanna Clothilde 3d's Clyde	30550	2	+0.099	50BA+50CC
38	King Pontiac Dione	82595	2	+0.085	50AB+50DC
39	Small Hopes Korndyke De Kol	32260	2	+0.070	100CB
40	Woodcrest Tehee	74219	10	+0.062	10AD+10BA+10BB+ 10CC+20DC+40DD
41	Leland Sarcastic	42451	2	+0.060	100DD
42	Prince Alcartra Korndyke	88318	2	+0.045	50BC+50CB
43	Sir Hengerveld De Kol Ormsby	31211	2	+0.045	50AB+50CA
44	King Segis Hengerveld Vale	60344	5	+0.044	20AB+20BB+20CC +20DB+20DC
45	Woodcrest Gordon Fayne	97208	2	+0.025	50BB+50DC
46	Emblagaard Tritomia Homestead	62924	5	+0.024	20CB+20CC+20CD +20DB+20DD
47	Piersma Albina Segis Lad	75361	2	+0.015	50BB+50DD
48	Sir Korndyke Hengerveld Canary	53825	2	+0.015	50CB+50CD

Holstein-Friesian sires in order of the net change in butter-fat percentage of their daughters over the butter-fat percentage of the dams of these daughters.—Continued.

No.	Name of Bull	No. Registry	of No. Pairs	Change Net %	Quartile Changes
49	Sarcastic Lad	23971	5	+0.012	20BC+20CC+20DC +40DD
50	Sir Johanna Piebe	53257	10	+0.009	10AB+40BB+20CB +30CC
51	Johanna Rue 2d's Paul De Kol	21724	4	+0.005	25BD+50CC+25DD
52	King Pontiac Champion	53418	14	+0.004	7AA+14AB+7AC+ 14BA+7CA+14CB+ 21CC+7CD+7DD
53	Johanna De Kol's Lad	26938	7	—0.004	43CB+14CD+14DC +29DD
54	Prince Gelsche Walker	81663	5	—0.008	20AB+40CC+20CD +20DB
55	King Champion Victoria	68544	5	—0.012	20AA+20AB+40BA +20CD
56	Colantha Johanna Champion	45674	2	—0.015	50AA+50BB
57	Prince Leo Aaltje	61435	3	—0.016	33AA+33BC+33BD
58	Aralia De Kol Pontiac Segis	112077	2	—0.030	50BB+50BC
59	Sir Pietertje Ormsby Mercedes	44931	12	—0.044	25AA+17AC+8BA+ 17BB+8BC+8CA+ 8CD+8DB
60	Korndyke Queen De Kol's Prince	26025	5	—0.056	20BB+20BC+20BD+ 20CA+20CC
61	Virginia Korndyke Butter Boy	128445	2	—0.060	50AB+50CC
62	Oak De Kol 2d Homestead Fobes	65750	2	—0.060	50BD+50DD
63	King Hengerveld Pondyke	47843	6	—0.073	33AA+17BC+17CB+ 17CC+17CD
64	Earl Korndyke De Kol	24954	2	—0.080	100BB
65	Sir Musser Clyde De Kol	40368	2	—0.080	50AA+50AB
66	Sir Walker Segis	50672	10	—0.081	10AD+20BC+20CB +30CC+10CD+10DD
67	Sir Korndyke Hengerveld De Kol 36th	85968	3	—0.087	33AA+33AB+33DC
68	Sir Concordia Korndyke	75012	2	—0.095	50CD+50DD
69	Sir Hengerveld Model Johanna	40338	6	—0.095	17AA+17AD+17CB+ 17CD+33DD
70	Paul Frenesta De Kol	41206	6	—0.096	17AC+17CB+17CC +50DD
71	Alma Prince Jewel	32731	2	—0.110	50BB+50BC
72	King Pontiac Ruby Burke	58041	2	—0.125	50BD+50DC
73	King Ormsby Parthenea	81630	3	—0.133	67AA+33DD
74	Pietje 22d Son	58314	2	—0.135	50AB+50BB
75	Colantha Johanna Lad	32481	2	—0.140	50BC+50DD
76	Masterpiece	84099	2	—0.145	50AB+50BB
77	Butter Boy Sir Mechthilde	37302	2	—0.150	100DD
78	Sir College Cornucopia	59755	2	—0.155	50BC+50DD
79	Sir Johanna De Kol	25467	4	—0.157	50BC+25BD+25CC
80	Duke Segis Inka Korndyke	49722	2	—0.180	50CD+50DD
81	Ormsby Korndyke Lad	102469	2	—0.180	50AA+50AC
82	Johanna De Colantha Champion	60574	13	—0.189	31AA+23AC+23BB+ 8BC+8CD+8DD
83	North Star Longfield Sir Beets	97403	2	—0.190	100BC
84	Sir Pietertje Lass De Kol	94292	5	—0.192	20AA+20AB+60DD
85	Johanna Colantha Sarcastic Lad	38402	5	—0.196	20BB+40BD+20DB +20DD
86	Sir Carlotta Pontiac Cronus	45592	4	—0.210	50AA+25AB+25AC
87	Sir Piebe Aaggie Hengerveld	32492	5	—0.214	60AA+20CD+20DD
88	White Segis De Kol	78027	2	—0.220	50AD+50CB
89	Sir Johanna Bonheur Fayne	45671	6	—0.220	33AB+33AC+17BB +17CC
90	Maplecrest Butter Boy De Kol	94156	2	—0.225	50AA+50BC
91	Sir Cornucopia Prince	48663	6	—0.236	17BB+50BC+17BD +17CD
92	Johanna Colantha's Lad	28296	2	—0.250	50AC+50BB
93	Sir Ormsby Skylark	47010	2	—0.250	50AD+50DC
94	Spring Farm King Pontiac 6th	103899	2	—0.260	50AC+50BB
95	Spring Farm King Pontiac 8th	114319	3	—0.264	67AB+33CC

Holstein-Friesian sires in order of the net change in butter-fat percentage of their daughters over the butter-fat percentage of the dams of these daughters.—Concluded.

No.	Name of Bull	Registry No.	No. of Pairs	Net Change %	Quartile Changes
96	King Segis Pontiac Count	93909	2	—0.265	50AC+50CC
97	King Beauty Pietertje De Kol	50758	2	—0.270	100AA
98	Dutchland Colantha Sir Inka	50999	4	—0.275	25AC+50BC+25BD
99	Star Farm Johanna Lad	45224	8	—0.277	38AA+13AD+13BC+25CB+13CC
100	Lakeside Model Alban	71013	2	—0.285	50BC+50CD
101	Aaggie Clothilde Bawn De Kol	33207	2	—0.300	50BD+50DD
102	Missouri Chief Josephine Lad	70857	3	—0.304	33CC+33CD+33DD
103	Sir Johanna Aaggie Posch 4th	72013	2	—0.335	50AB+50AC
104	Sir Johanna Fayne	42147	2	—0.350	50BB+50BD
105	Quirinus Cornucopia	60751	2	—0.385	50AC+50BB
106	Segis Pontiac De Kol Burke	97472	5	—0.402	20AA+20AB+20AD+20CC+20DD
107	Palost Pontiac Champion	105106	2	—0.425	100BD
108	Mutual Piebe De Kol	44554	4	—0.427	25AB+25BD+50CD
109	Ladoga King Veeman De Kol	43496	2	—0.460	50AB+50BD
110	Hygeia Veeman Butter Boy	43697	2	—0.510	50AB+50AD
111	Aaggie Cornucopia Johanna Lad Jr.	36974	2	—0.980	50AD+50BD

cows were from C class dams. In this case there were only 2 daughter-dam pairs to base this judgment as to the bull's worth, but even so, the probable errors shown in Table 3 indicate that in this case the rise is probably significant in the statistical sense.

Consideration of the records given in Table 6 in conjunction with the probable error as given in Table 3, shows that there are only 7 sires with record daughters significantly[10] above those of their dams. These sires were Kalmuck Skylark Johanna, Romeo Aaggie Acme of Riverside, Juliana King of Riverside, Paul Cornucopia Mercedes Aaggie, Prince Ormsby Mercedes De Kol, and Maple Crest Pontiac Hartog. There were but two sires with daughters whose butter-fat percentages were significantly below those of their dams. These sires were Aaggie Cornucopia Johanna Lad Jr. and Segis Pontiac De Kol Burke.

The pedigree of Kalmuck Skylark Johanna is given below

For comparative purposes two groups of sires have been chosen. The first group has daughters with butter-fat percentages at least 2 times the probable error, as shown in Table 3, greater than those of their dams. The second group of sires has daughters with butter-fat percentage at least 2 times the

[10]The record 3 times its probable error.

probable error less than their dams. The first group of sires improved their daughters' butter-fat percentage. The second decreased it.

Pedigree of Kalmuck Skylark Johanna 48832.

Maine Agr. Exp. Sta.—Standard Pedigree Blank

Sheet No. +

Sex ♂

No. 48832 Kalmuck Skylark Johanna

♂ No. 33242 Sir Skylark Johanna

♀ No. 68099 Katy Gerben

No. 26937 ♂ Sir Johanna	No. 23971 ♂ Sarcastic Lad	No. 22394 ♂ Maurice Bonheur	
		No. 23039 ♀ Belle Sarcastic	
	No. 45164 ♀ Johanna Friend	No. 18726 ♂ Paul Mutual De Kol	
		No. 30836 ♀ Johanna 5ths Clothilde	
No. 20009 ♀ Skylark 2d	No. (1115 H.H.B.) ♂ Friesland Boy	No. ♂	
		No. ♀	
	No. (10167 H.H.B.) ♀ Skylark	No. 3190 H.H.B. ♂ Lord Ripon	
		No. 6579 H. H. B. ♀ Sibbel	
No. 28905 ♂ Baronet Gerben 2d	No. 26983 ♂ Baronet Gerben	No. 24269 ♂ Gold Leaf 2d Gerben Sir Henry	
		No. 40800 ♀ Baroness Rose	
	No. 46508 ♀ Sharon Queen	No. 24448 ♂ Mechthilde Sir Henry's Gerben	
		No. 40146 ♀ Sharon Maid	
No. 55815 ♀ Karen 2d	No. 20994 ♂ Clothilde Chief	No. 18410 ♂ Oat Ka Chief	
		No. 31869 ♀ Figridia's Clothilde	
	No. 11902 ♀ Karen	No. 4261 H.H.B. ♂ Sir Rans	
		No. 428 ♀ Mantema 2d	

Table 7 shows that there are 15 sires which increase their daughters' butter-fat percentage, at least 2 times the probable error of such increase, over the butter-fat percentage of their dams. Within the group that decrease their daughters' butter-fat percentage there are 7 sires. These groups are significantly differentiated. The data pertaining to the inbreeding and relationship occurring in the pedigrees of the first group of these sires are given in Table 7.

The inbreeding and relationship for the sires which increase their daughters' butter-fat percentage and for the sires which decrease their daughters' butter-fat percentage is given in Table 7. Comparison of these results shows that the inbreeding and relationship of the two groups is on the whole small in amount. The sires which lower the butter-fat test of their daughters have

more inbreeding and relationship than the sires which raised their daughters' test. When the differences between the two groups are compared with their probable errors, as calculated from the standard deviations given in the previous paper[11] of this series, these differences are found not significant. A similar comparison of the inbreeding and relationship as shown by the random sample sires of this paper with the inbreeding and relationship

TABLE 7.

Inbreeding and relationship existing in the four generation pedigrees of sires increasing or decreasing the butter-fat percentage of their daughters over that of their dams.

Sires increasing the butter-fat percentage (group 3)

No.	Name	Reg. No.	Z	Z_2	Z_3	Z_{T3}	K_2	K_3	K_4
1	Kalmuck Skylark Johanna	48832	0	0	0	0	0	0	0
2	Romeo Aaggie Acme of Riverside	32422	0	0	18.8	8.8	0	0	0
3	Juliana King of Riverside	38446	0	0	6.3	3.0	0	0	12.5
4	Paul Cornucopia Mercedes Aaggie	94884	0	0	12.5	5.9	0	0	12.5
5	Canary Mercedes Paul	29600	0	0	0	0	0	0	0
6	Prince Ormsby Mercedes De Kol	47008	0	0	12.5	10.0	0	0	12.5
7	Maple Crest Pontiac Hartog	62178	0	12.5	12.5	10.0	0	25.0	25.0
8	Pontiac Aaggie Korndyke	38291	0	0	0	0	0	0	0
9	Johan Woodcrest Lad	52145	0	0	0	0	0	0	0
10	King Pietertje Cloverdale	69686	0	0	0	0	0	0	0
11	Homestead Girl De Kol Sarcastic Lad	32558	0	0	0	0	0	0	0
12	King Mead of Riverside	50290	0	0	0	0	0	0	0
13	Gem Pietertje Paul De Kol 3d	44658	0	0	0	0	0	0	0
14	Sir Korndyke Hengerveld De Kol	41266	0	0	12.5	5.9	0	0	25.0
15	Sir Homestead Posch De Kol	37314	0	0	0	0	0	0	0
	Mean		0	.8	5.0	2.9	0	1.7	5.8

Sires decreasing the butter-fat percentage (group 4)

1	Aaggie Cornucopia Johanna Lad Jr.	36974	0	12.5	12.5	10.0	0	25.0	25.0
2	Hygeia Veeman Butter Boy	43697	0	0	6.3	3.0	0	0	0
3	Ladoga King Veeman De Kol	43496	0	0	6.3	3.0	0	0	0
4	Mutual Piebe De Kol	44554	0	0	12.5	10.0	0	0	12.5
5	Segis Pontiac De Kol Burke	97472	0	0	12.5	5.9	0	0	0
6	Star Farm Johanna Lad	45224	0	0	12.5	5.9	0	0	12.5
7	Johanna De Colantha Champion	60574	0	12.5	25.0	17.7	0	25.0	37.5
	Mean .		0	3.6	12.5	7.9	0	7.1	12.5

[11]Gowen, John W. and Covell, Mildred R. 1921. Studies in Milk Secretion. IX. On the Performance of the Progeny of Holstein-Friesian Sires. Annual Report of the Maine Agricultural Experiment Station for 1921. Bulletin 300.

constants for these groups showed that these groups are not significantly differentiated. From this, it may be concluded that as normally carried on within the Holstein-Friesian breed, inbreeding and relationship within a sire's pedigree show no significant effect on the production or butter-fat test of his offspring.

The groups of sires in Table 7 were also examined to determine if the ancestors within one group were differentiated from those within the other. Here again it should be kept constantly in mind that these groups are small in numbers and subject to considerable variation because of the agencies of chance.

The bulls occurring 3 or more times within the pedigrees of the sires which increased their daughters' butter-fat percentage were De Kol 2d's Paul De Kol (7-3), Paul De Kol (3-4), Maurice Bonheur (3-1), Sarcastic Lad (3-1), De Kol 2d's Alban (3-1), Willem III (1-3), Sir Henry Beatus (2-2), Milla's Pietertje Netherland (2-1), De Kol 2d's Butter-Boy (2-1), Pietertje Hengerveld's Paul De Kol (3-0), Tritomia's Netherland Carl (3-0), Romeo Aaggie (1-2), Empress Josephine 3d's Sir Mechthilde (2-1), Lord Netherland De Kol (1-2).

The cows occurring 3 or more times in the same group were De Kol 2d (4-5), Napoli (2-2), Homestead Girl (2-2), Homestead Girl De Kol (2-2), De Kol (1-3), Belle Sarcastic (3-1), Pietertje Hengerveld (3-0), Netherland Hengerveld (2-1).

The bulls occurring 2 or more times in the group of sires which decrease the butter-fat percentage of their daughters are *Paul De Kol* (4-5), *De Kol 2d's Paul De Kol* (2-4), Aaggie Cornelia 5th's Clothilde Imperial (3-2). *Pietertje Hengerveld's Paul De Kol* (0-2), *Milla's Pietertje Netherland* (1-1), *De Kol 2d's Butter Boy* (0-2), *Willem III* (2-0), *Sarcastic Lad* (2-0), *Maurice Bonheur* (2-0), Homestead Jr. De Kol (1-1) Hamilton (1-1), Inka 5th's Pietertje (1-1), Pietertje Paul (1-1), Paul De Kol 3d (1-1), Paul De Kol Jr. (1-1), De Kol Burke (0-2), Netherland Alban (1-1), Pontiac Korndyke (2-0), Paul Mutual De Kol (0-2), Sir Abbekerk (0-2), Johanna Aaggie's Sarcastic Lad (2-0), Aaltje Salo 3d's Tritomia Netherland (1-1).

The cows for the same group are *De Kol 2d* (5-3), Sadie Vale Concordia (1-2), Pleasant Valley Maid (2-0), Johanna 4th (2-0), Johanna Aaggie (2-0), *De Kol* (2-0), *Belle Sarcastic* (2-0), Sadie Vale 2d (1-1), Jessie Veeman A (1-1), 5th Darkje Veeman (1-1), Jessie Veeman (1-1), Jessie Veeman 2d (1-1),

Homestead Heroine De Kol (1-1), Colantha 4th (1-1), Colantha (1-1).

After the name of each sire is given in parenthesis first the number of appearances on the sire's side of the pedigree and second the number of appearances on the dam's side of the pedigree. There are certain of the bulls and cows italicized in the list of repeating ancestors for the sires which decrease the butter-fat percentage of their daughters. These animals are also found in the list of ancestors which increase the butter-fat percentage of their daughters. It will be noted, that in general, the bulls most often repeated in one group are also repeated in the other. The chance for the repetition of a cow is not as great as that for a bull. Even here with only 7 pedigrees in the second group, it is found that three cows are repeated in the two groups. Such being the case, it appears that the presence of a famous animal in the third or fourth generation of a pedigree has little or no significance for it cannot be argued therefrom that the animal pedigreed will also be great or near great.

This conclusion is emphasized when comparison is made between the animals of the random sample group[12] and those of these two groups, for here again the same general principle is found to hold. The animals present most frequently in either of the above groups are also present in the pedigrees of the sires who have no advanced registry daughters.

The Transmitting Qualities of Holstein-Friesian Sires for Net Butter-Fat.

The quantity of butter-fat produced is a function of the two variables, amount of milk and percentage of fat in the milk. Since this is so, the heading of the section could with equal propriety be the net change in the butter-fat from mother to daughter of the daughters of Holstein-Friesian sires.

The arrangement of the table to show this relation for Holstein-Friesian sires differs from the preceding tables in that the column for the quartiles is omitted as being superfluous since these data have been given in Tables 4 and 6 for the two variables on which the amount of butter-fat depends. The first column of Table 8 gives the place occupied by the bull in the series of bulls.

[12]See paper on studies on milk secretion. IX.

The second and third columns give the name and registry number of the bull. The fourth column states how many pairs of daughter-dam tests the bull under discussion had. The fifth column gives the number of pounds of butter-fat that the bull's daughters are in excess or defect of their dams. It is by this column that the bulls are arranged, the bull whose daughters produced the most butter-fat over the butter-fat production of their dams coming at the top of the list. The plus sign shows the daughters produced more butter-fat than their dams, the minus sign that they produced less butter-fat.

TABLE 8.

Holstein-Friesian sires in order of change of net butter-fat between daughters and their dams.

No.	Name of Bulls	Registry No.	No. of Pairs	Net Change
1	Ormsby Korndyke Lad	102469	2	+239.75 lbs.
2	Johan Woodcrest Lad	52145	3	+239.47 lbs.
3	Emblagaard Tritomia Homestead	62924	5	+227.46 lbs.
4	Colantha Johanna Champion	45674	2	+221.21 lbs.
5	Alcartra Polkadot Corrector	30624	2	+182.21 lbs.
6	Sir Korndyke Hengerveld De Kol	41266	6	+173.00 lbs.
7	King Pontiac Champion	53418	14	+170.40 lbs.
8	King Segis Pontiac Count	93909	2	+150.37 lbs.
9	Korndyke Netherland Wayne De Kol	47306	2	+150.10 lbs.
10	Homestead Girl De Kol Sarcastic Lad	32558	4	+143.18 lbs.
11	King Pietertje Cloverdale	69686	3	+140.28 lbs.
12	Greenwood Johanna Lyons	62049	2	+137.76 lbs.
13	Prince Pietertje Beryl	46977	2	+137.06 lbs.
14	Sir Johanna De Kol	25467	4	+134.14 lbs.
15	Sir Hengerveld Model Johanna	40338	6	+131.00 lbs.
16	Woodcrest Tehee	74219	10	+121.63 lbs.
17	Hygeia Veeman Butter Boy	43697	2	+118.21 lbs.
18	King Segis Hengerveld Vale	60344	5	+117.18 lbs.
19	Masterpiece	84099	2	+102.05 lbs.
20	King Mead of Riverside	50290	6	+ 98.08 lbs.
21	Pietertje Hengerveld Sir Korndyke	60966	5	+ 94.16 lbs.
22	Kalmuck Skylark Johanna	48832	2	+ 92.72 lbs.
23	King of the Pontiacs	39037	3	+ 91.84 lbs.
24	Pontiac Aaggie Korndyke	38291	2	+ 90.58 lbs.
25	Sir Korndyke Hengerveld Canary	53825	2	+ 89.43 lbs.
26	King Beauty Pietertje De Kol	50758	2	+ 88.24 lbs.
27	Canary Paul	48328	3	+ 85.58 lbs.
28	Sir Johanna Piebe	53257	10	+ 82.85 lbs.
29	Gem Pietertje Paul De Kol 3d	44658	5	+ 81.37 lbs.
30	Virginia Korndyke Butter Boy	128445	2	+ 78.37 lbs.
31	Johanna Colantha's Lad	28296	2	+ 78.15 lbs.
32	Johanna Colantha Sarcastic Lad	38402	5	+ 74.61 lbs.
33	Downing Johanna Burke De Kol	84472	2	+ 73.60 lbs.
34	Paul Frenesta De Kol	41206	6	+ 72.74 lbs.
35	Sir Cornucopia Prince	48663	6	+ 69.26 lbs.
36	Juliana King of Riverside	38446	3	+ 68.17 lbs.
37	Sir Ormsby Skylark	47010	2	+ 65.72 lbs.
38	Dutchland Sir Pietertje Hengerveld	48696	2	+ 64.50 lbs.
39	Prince Gelsche Walker	81663	5	+ 60.43 lbs.
40	Aaggie Clothilde Bawn De Kol	33207	2	+ 60.24 lbs.
41	Butter Boy Sir Mechthilde	37302	2	+ 59.14 lbs.
42	Mooie Oak De Kol 2d	60278	2	+ 57.83 lbs.
43	Aaggie Cornucopia Pauline Count 13th	44293	4	+ 54.47 lbs.

Holstein-Friesian sires in order of change of net butter-fat between daughters and their dams.—Concluded.

No.	Name of Bulls	Registry No.	No. of Pairs	Net Change
44	Prince Ormsby Mercedes De Kol	47008	3	+ 46.41 lbs.
45	Hartog Paul Burke	49910	3	+ 45.63 lbs.
46	King Oak Grove	42235	2	+ 43.91 lbs.
47	Small Hopes Korndyke De Kol	32260	2	+ 43.62 lbs.
48	Sir Winana Beets Segis	52927	2	+ 37.81 lbs.
49	Sir Pietertje Lass De Kol	94292	5	+ 35.40 lbs.
50	Sir Walker Segis	50672	10	+ 33.93 lbs.
51	Johanna Rue 2d's Paul De Kol	21724	4	+ 32.37 lbs.
52	Knight Errant	39566	2	+ 30.07 lbs.
53	King Ormsby Parthenea	81630	3	+ 25.92 lbs.
54	Segis Pontiac De Kol Burke	97472	5	+ 21.44 lbs.
55	Dutchland Colantha Sir Inka	50999	4	+ 19.85 lbs.
56	Paul Cornucopia Mercedes Aaggie	94884	4	+ 19.16 lbs.
57	Sir Homestead Posch De Kol	37314	7	+ 18.61 lbs.
58	Prince Leo Aaltje	61435	3	+ 18.11 lbs.
59	Canary Mercedes Paul	29630	2	+ 17.74 lbs.
60	Spring Farm King Pontiac 8th	114319	3	+ 17.68 lbs.
61	Pietje 22d's Woodcrest Lad	39849	2	+ 16.46 lbs.
62	Johanna De Kol's Lad	26038	7	+ 15.89 lbs.
63	Star Farm Johanna Lad	45224	8	+ 12.76 lbs.
64	Sarcastic Lad	23971	5	+ 10.41 lbs.
65	King Champion Victoria	68544	5	+ 8.65 lbs.
66	Sir Johanna Fayne	42147	2	+ 5.86 lbs.
67	Sir Pietertje Ormsby Mercedes	44931	12	+ 4.53 lbs.
68	Korndyke Queen De Kol's Prince	26925	5	+ 3.11 lbs.
69	Johanna Clothilde 3d's Clyde	30550	2	+ 2.11 lbs.
70	White Segis De Kol	78027	2	+ 1.75 lbs.
71	Woodcrest Gordon Fayne	97208	2	+ 1.32 lbs.
72	Sir Carlotta Pontiac Cronus	45592	4	— .27 lbs.
73	Quirinus Cornucopia	60751	2	— 6.83 lbs.
74	Sir Johanna Aaggie Posch	38401	5	— 10.07 lbs.
75	Duke Segis Inka Korndyke	49722	2	— 10.23 lbs.
76	Aralia De Kol Pontiac Segis	112077	2	— 19.40 lbs.
77	North Star Longfield Sir Beets	97403	2	— 25.12 lbs.
78	Piersma Albina Segis Lad	75361	2	— 26.26 lbs.
79	Sir Piebe Aaggie Hengerveld	32492	5	— 27.46 lbs.
80	Prince Alcartra Korndyke	88318	2	— 28.87 lbs.
81	Spring Farm King Pontiac 6th	103899	2	— 31.34 lbs.
82	Sir Hengerveld De Kol Ormsby	31211	2	— 32.01 lbs.
83	Sir Musser Clyde De Kol	40368	2	— 38.01 lbs.
84	Woodcrest Pietje	35469	2	— 38.03 lbs.
85	King Hengerveld Pondyke	47843	6	— 39.09 lbs.
86	Colantha Johanna Lad	32481	2	— 45.85 lbs.
87	Sir Concordia Korndyke	75012	2	— 50.59 lbs.
88	Aaggie Cornucopia Johanna Lad Jr.	36974	2	— 51.84 lbs.
89	Earl Korndyke De Kol	24954	2	— 56.35 lbs.
90	Sir Johanna Bonheur Fayne	45671	6	— 56.79 lbs.
91	Missouri Chief Josephine Lad	70857	3	— 61.09 lbs.
92	King Pontiac Dione	82505	2	— 64.20 lbs.
93	Maplecrest Butter Boy De Kol	94156	2	— 73.48 lbs.
94	Johanna De Colantha Champion	60574	13	— 74.55 lbs.
95	Maple Crest Pontiac Hartog	62178	3	— 82.32 lbs.
96	King Pontiac Ruby Burke	58341	2	— 82.69 lbs.
97	Sir College Cornucopia	59755	2	— 86.64 lbs.
98	Mutual Piebe De Kol	44554	4	— 87.82 lbs.
99	Rag Apple Korndyke De Kol	67211	2	— 93.61 lbs.
100	Sir Aaggie Cornucopia Segis	76665	2	—109.87 lbs.
101	Oak De Kol 2d Homestead Fobes	65750	2	—114.30 lbs.
102	Pabst Pontiac Champion	105106	2	—114.73 lbs.
103	Sir Segis Mutual Walker	80916	2	—116.80 lbs.
104	Sir Korndyke Hengerveld De Kol 36th	85968	3	—122.93 lbs.
105	Sir Johanna Aaggie Posch 4th	72913	2	—149.39 lbs.
106	Pietje 22d Son	58314	2	—150.04 lbs.
107	Alma Prince Jewel	32731	2	—152.81 lbs.
108	Lakeside Model Alban	71913	2	—159.48 lbs.
109	Romeo Aaggie Acme of Riverside	32422	2	—187.03 lbs.
110	Leland Sarcastic	42451	2	—209.13 lbs.
111	Ladoga King Veeman De Kol	43496	2	—230.55 lbs.

Ormsby Korndyke Lad heads the list of sires which raises the butter-fat of their offspring. This is largely because of the phenomenal increase which he gave his daughters in their milk yield. A close second to Ormsby Korndyke Lad is Johan Woodcrest Lad. This bull's daughters' net increase in butter-fat over their dams is large because of another reason, namely, that this bull raised both the milk yield and butter-fat percentage of his daughter to a considerable degree. Other considerations enter in comparing these records. Ormsby Korndyke Lad was bred to better dams than was Johan Woodcrest Lad. Thus in Table 4 Ormsby Korndyke Lad is seen to be bred to 1 A class and I D class dam whereas Johan Woodcrest Lad was bred to only D class dams. Similarly in Table 6 Ormsby Korndyke Lad is seen to be bred to A class dams for butter-fat percentage, whereas, again Johan Woodcrest Lad is bred to D class dams. Ormsby Korndyke Lad is handicapped in each case. From the point of view of the owners, who have them in their herds these bulls are of about equal value in increasing the butter-fat of their offspring.

There are 111 sires given in Table 8. Seventy-one or 16 more than half raise the butter-fat yield of their daughters. The range of increase and decrease in yield is about the same 239.75 for the increase and 230.55 for the decrease.

Examination of the table shows that sons of the same sire may raise, maintain or lower the butter-fat of their daughters. Thus, Sir Fayne Concordia has three sons; one of these, Sir Johanna Fayne maintains the butter-fat of his daughters; Sir Johanna Bonheur Fayne decreases the butter-fat yield of his daughters and the third son Colantha Johanna Champion increases the butter-fat of his daughters. The manner in which the sons of a given sire affect the milk yield, butter-fat percentage and butter-fat of their daughters is given in Table 9 of the next section.

TRANSMITTING QUALITIES OF HOLSTEIN-FRIESIAN SIRES TO THEIR SONS.

In this section we deal with the sire whose sons' transmitting qualities for quantity and quality of milk production are known through the progeny tests of their daughters. For this purpose Table 9 has been made. The arrangement of this table is made

on the basis of how much butter-fat the sire's son or sons caused his daughters to produce in excess or defect of their dams. The mean of each item is taken for each sire's son if he has more than one son of known transmitting powers. The information in this table is as follows: (1) The number which the sire takes in the series of sires, because of the butter-fat transmitting qualities of his sons is given in the first column; (2) the sire's name is given; (3) immediately under the sire's name is given the sons' names each one of which is indented; (4) beside each bull's name is given his registry number, the number of daughter-dam pairs that he has, the net change in the milk production which his daughters produced in comparison with that of their dams, the net change in the butter-fat percentage and the net change in the butter-fat.

TABLE 9.

Holstein-Friesian sires in order of the average net change in butter-fat of their sons' daughters over the butter-fat of the dams of these daughters.

No.	Names of Sire and Sons	Registry No.	No. of Pairs	Net Change in Milk	Net Change in %	Net Change in Fat
1	King Korndyke Hengerveld Ormsby	53822	--	------	------	------
	Ormsby Korndyke Lad	102469	2	+7637.5	—0.180	+239.75
2	Homestead Jr. De Kol	28400	--	------	------	------
	Emblagaard Tritomia Homestead	62924	5	+6716.4	+0.024	+227.46
3	Chief Piebe Oak Duchess	28176	--	------	------	------
	Alcartra Polkadot Corrector	30624	2	+3420.5	+0.405	+182.21
4	Hengerveld De Kol	23102	--	------	------	------
	Sir Hengerveld Model Johanna	40338	6	+4489.0	—0.095	+131.00
	Sir Korndyke Hengerveld De Kol	41266	6	+3665.7	+0.259	+173.00
	Mean			+4077.3	+0.082	+152.00
5	Korndyke Wayne Paul De Kol	32571	--	------	------	------
	Korndyke Netherland Wayne De Kol	47306	2	+2285.5	+0.360	+150.10
6	Johanna Aaggie's Sarcastic Lad	26935	--	------	------	------
	Homestead Girl De Kol Sarcastic Lad	32558	4	+1995.5	+0.338	+143.18
7	Lyons Hengerveld Count De Kol	40592	--	------	------	------
	Greenwood Johanna Lyons	62049	2	+2057.0	+0.340	+137.76
8	Beryl Wayne's Paul De Kol	26766	--	------	------	------
	Prince Pietertje Beryl	46977	2	+1500.0	+0.420	+137.06
9	Sir Johanna	23446	--	------	------	------
	Sir Johanna De Kol	25467	4	+4755.8	—0.157	+134.14
10	De Kol's 2d's Butter Boy 3d	23260	--	------	------	------
	Hygeia Veeman Butter Boy	43697	2	+5308.5	—0.510	+118.21
11	King Fayne Segis	46767	--	------	------	------
	Masterpiece	84099	2	+3791.5	—0.145	+102.05
12	Juliana King of Riverside	38446	3	—2351.3	+0.637	+ 68.17
	King Mead of Riverside	50290	6	+ 871.5	+0.304	+ 98.08
13	Faforit Tritomia Sir Korndyke	36324	--	------	------	------
	Pietertje Hengerveld Sir Korndyke	60966	5	+2040.8	+0.116	+ 94.16
14	Sir Skylark Johanna	33242	--	------	------	------
	Kalmuck Skylark Johanna	48832	2	— 332.0	+0.665	+ 92.72

Holstein-Friesian sires in order of the average net change in butter-fat of their sons' daughters over the butter-fat of the dam of these daughters.—Continued.

No.	Names of Sire and Sons	Registry No.	No. of Pairs	Net Change in Milk	Net Change in %	Net Change in Fat
15	Pontiac Korndyke	25982	--	------	------	------
	Pontiac Aaggie Korndyke	38291	2	— 700.5	+0.465	+ 90.58
	King of the Pontiacs	39037	3	+1789.7	+0.113	+ 91.84
	Mean			+ 544.6	+0.289	+ 91.21
16	Royal De Kol Pietertje King	41296	--	------	------	------
	King Beauty Pietertje De Kol	50758	2	+3580.0	—0.270	+ 88.24
17	Sir Homestead Posch De Kol	37314	7	— 602.5	+0.236	+ 18.61
	King Pietertje Cloverdale	69686	3	+1817.0	+0.354	+140.28
	Sir Pietertje Lass De Kol	94292	5	+2061.6	—0.192	+ 35.40
	Mean			+1939.3	+0.081	+ 87.84
18	Pietertje Hengerveld's Paul De Kol	22128	--	------	------	------
	Canary Paul	48328	3	+ 990.0	+0.306	+ 85.58
19	Sir Johanna Ruth	42142	--	------	------	------
	Sir Johanna Piebe	53257	10	+2338.4	+0.009	+ 82.85
20	Gem Pietertje Paul De Kol	27282	--	------	------	------
	Gem Pietertje Paul De Kol 3rd	44658	5	+ 900.8	+0.290	+ 81.37
21	Albina Butter Boy	64755	--	------	------	------
	Virginia Korndyke Butter Boy	128445	2	+2583.5	—0.060	+ 78.37
22	Kate Spray 3d Johanna	56688	--	------	------	------
	Downing Johanna Burke De Kol	84472	2	+1196.0	+0.200	+ 73.60
23	Mutual Pietertje Paul	31943	--	------	------	------
	Paul Frenesta De Kol	41206	6	+2744.0	—0.096	+ 72.74
24	Fidessa Butter Boy	32429	--	------	------	------
	Juliana King of Riverside	38446	3	—2351.3	+0.637	+ 68.17
25	King Segis	36168	--	------	------	------
	Sir Walker Segis	50672	10	+1458.3	—0.081	+ 33.93
	King Segis Hengerveld Vale	60344	5	+3176.4	+0.044	+117.18
	Sir Winana Beets Segis	52927	2	+ 79.0	+0.220	+ 37.81
	Mean			+1571.2	+0.061	+ 62.97
26	Pietertje Hengerveld's Count De Kol	23224	--	------	------	------
	Aaggie Clothilde Bawn De Kol	33207	2	+3386.5	—0.300	+ 60.24
	Dutchland Sir Pietertje Hengerveld	48696	2	—1508.5	+0.400	+ 64.50
	Mean			+ 939.0	+0.050	+ 62.37
27	Beauty Pietertje Prince	56435	--	------	------	------
	Prince Gelsche Walker	81663	5	+1865.0	—0.008	+ 60.43
28	Butter Boy Pietertje	26533	--	------	------	------
	Butter Boy Sir Mechthilde	37302	2	+2949.0	—0.150	+ 59.14
29	Mooie Oak De Kol	40536	--	------	------	------
	Mooie Oak De Kol 2d	60278	2	— 270.5	+0.395	+ 57.83
30	Sir Fayne Concordia	35227	--	------	------	------
	Sir Johanna Fayne	42147	2	+2049.5	—0.350	+ 5.86
	Sir Johanna Bonheur Fayne	45671	6	— 383.3	—0.220	— 56.79
	Colantha Johanna Champion	45674	2	+6079.0	—0.015	+221.21
	Mean			+2581.7	—0.195	+ 56.76
31	Sir Ormsby Hengerveld De Kol	31212	--	------	------	------
	Prince Ormsby Mercedes De Kol	47008	3	—1827.3	+0.553	+ 46.41
	Sir Ormsby Skylark	47010	2	+3417.0	—0.250	+ 65.72
	Mean			+ 794.9	+0.151	+ 56.06
32	Aaggie Cornucopia Pauline Count	29642	--	------	------	------
	Aaggie Cornucopia Pauline Count 13th	44293	4	+ 448.0	+0.210	+ 54.47
33	Homestead Girl De Kol Sarcastic Lad	32558	4	+1995.5	+0.338	+143.18
	Pietje 22d's Woodcrest Lad	39849	2	—1120.5	+0.290	+ 16.46
	Star Farm Johanna Lad	45224	8	+1578.5	—0.277	+ 12.76
	Johan Woodcrest Lad	52145	3	+5140.0	+0.413	+239.47
	Pietje 22d Son	58314	2	—3467.5	—0.135	—150.04
	Woodcrest Tehee	74219	10	+3357.6	+0.062	+121.63
	Mean			+1097.6	+0.071	+ 48.06
34	Hartog Pauline De Kol Count	28433	--	------	------	------
	Hartog Paul Burke	49910	3	+ 520.0	+0.297	+ 45.63
35	Duchess Ormsby Piebe Burke	29328	--	------	------	------
	King Oak Grove	42235	2	— 732.5	+0.425	+ 43.91
36	King Segis Pontiac	44444	--	------	------	------
	King Pontiac Dione	82505	2	—2321.0	+0.085	— 64.20
	King Segis Pontiac Count	93909	2	+6388.0	—0.265	+150.37
	Mean			+2033.5	—0.090	+ 43.08

Holstein-Friesian sires in order of the average net change in butter-fat of their sons' daughters over the butter-fat of the dam of these daughters.—Continued.

No.	Names of Sire and Sons	Registry No.	No. of Pairs	Net Change in Milk	Net Change in %	Net Change in Fat
37	Paul Mutual De Kol	18726	--	------	------	------
	Johanna Rue 2d's Paul De Kol	21724	4	+ 975.2	+0.005	+ 32.37
38	Piebe Paul	31954	--	------	------	------
	Knight Errant	39566	2	+ 89.5	+0.145	+ 30.07
38	King Ormsby	54424	--	------	------	------
	King Ormsby Parthenea	81630	3	+1445.0	—0.133	+ 25.92
40	Colantha Johanna Lad	32481	2	— 279.0	—0.140	— 45.85
	Dutchland Colantha Sir Inka	50999	4	+2249.7	—0.275	+ 19.85
41	Paul Cornucopia Mercedes De Kol 3d	68834	--	------	------	------
	Paul Cornucopia Mercedes Aaggie	94884	4	—2985.8	+0.375	+ 19.16
42	Alta Posch's Son	30154	--	------	------	------
	Sir Homestead Posch De Kol	37314	7	— 602.5	+0.236	+ 18.61
43	Aaltje Salo Mercedes De Kol Prince	39357	--	------	------	------
	Prince Leo Aaltje	61435	3	+ 591.7	—0.016	+ 18.11
44	Calamity Jane's Paul A	26250	--	------	------	------
	Canary Mercedes Paul	29600	2	—3053.5	+0.560	+ 17.74
45	King of the Pontiacs	39037	3	+1789.7	+0.113	+ 91.84
	King Hengerveld Pondyke	47843	6	— 779.5	—0.073	— 39.99
	King Pontiac Champion	53418	14	+4862.1	+0.004	+170.40
	King Pontiac Ruby Burke	58041	2	—1728.0	—0.125	— 82.69
	Mean			+ 784.9	—0.064	+ 16.20
46	Maurice Bonheur	22394	--	------	------	------
	Sarcastic Lad	23971	5	+ 280.4	+0.012	+ 10.41
47	Aaggie Cornucopia Johanna Lad	32554	--	------	------	------
	Aaggie Cornucopia Johanna Lad Jr.	36974	2	+4544.0	—0.980	— 51.84
	Sir Cornucopia Prince	48663	6	+3291.0	—0.236	+ 69.26
	Mean			+3917.5	—0.608	+ 8.71
48	Korndyke Queen De Kol's Prince	26025	5	+ 434.6	—0.056	+ 3.11
	Prince Alcartra Korndyke	88318	2	—1114.0	+0.045	— 28.87
	Small Hopes Korndyke De Kol	32269	2	+ 979.5	+0.070	+ 43.62
	Mean			— 67.3	+0.057	+ 7.38
49	Jack Mercedes	35077	--	------	------	------
	Sir Pietertje Ormsby Mercedes	44931	12	+ 403.3	—0.044	+ 4.53
50	Lorraine Prince	23109	--	------	------	------
	Korndyke Queen De Kol's Prince	26025	5	+ 434.6	—0.056	+ 3.11
51	Crown Prince Segis	52348	--	------	------	------
	White Segis De Kol	78027	2	+1709.0	—0.220	+ 1.75
52	Count Hengerveld Johanna Fayne	68591	--	------	------	------
	Woodcrest Gordon Fayne	97298	2	— 80.0	+0.025	+ 1.32
53	King Segis Pontiac Emperor	72287	--	------	------	------
	Segis Pontiac De Kol Burke	97472	5	+3908.6	—0.432	+ 21.44
	Aralia De Kol Pontiac Segis	112977	2	— 369.0	—0.030	— 19.49
	Mean			+1319.8	—0.216	+ 1.27
54	Pontiac Cronus	28835	--	------	------	------
	Sir Carlotta Pontiac Cronus	45502	4	+ 835.2	—0.210	— .27
55	Spring Farm King Pontiac	66664	--	------	------	------
	Spring Farm King Pontiac 6th	103899	2	+1902.0	—0.269	— 31.34
	Spring Farm King Pontiac 8th	114319	3	+1744.4	—0.264	+ 17.68
	Mean			+1373.2	—0.262	— 6.83
56	Sir Tchee Cornucopia	38978	--	------	------	------
	Quirinus Cornucopia	60751	2	+2441.5	—0.385	— 6.83
57	Sir Aaltje Posch	31789	--	------	------	------
	Sir Johanna Aaggie Posch	38491	5	—1655.2	+0.258	— 10.07
58	Prince Segis Korndyke	38835	--	------	------	------
	Duke Segis Inka Korndyke	49722	2	+ 538.0	—0.189	— 10.23
59	Sir Korndyke Hengerveld De Kol	41266	6	+3665.7	+0.259	+173.99
	Sir Korndyke Hengerveld Canary	53825	2	+2643.0	+0.015	+ 80.43
	Sir Korndyke Hengerveld De Kol 36th	85998	3	—2975.3	—0.087	—122.93
	Mean			— 166.1	—0.036	— 16.75
60	Sarcastic Lad	23971	5	+ 280.4	+0.012	+ 10.41
	Johanna De Kol's Lad	26938	7	+ 521.3	—0.004	+ 15.89
	Johanna Colantha's Lad	28296	2	+3595.0	—0.230	+ 78.15
	Colantha Johanna Lad	32481	2	— 279.0	—0.140	— 45.85

Holstein-Friesian sires in order of the average net change in butter-fat of their sons' daughters over the butter-fat of the dam of these daughters.—Concluded.

No.	Names of Sire and Sons	Registry No.	No. of Pairs	Net Change in Milk	Net Change in %	Net Change in Fat
	Johanna Colantha Sarcastic Lad	38402	5	+3486.6	—0.196	+ 74.61
	Leland Sarcastic	42451	2	—7443.0	+0.060	—209.13
	Mean			— 23.8	—0.106	— 17.26
61	Paul Clyde	27041	--	------	------	------
	Johanna Clothilde 3d's Clyde	30550	2	— 370.5	+0.090	+ 2.11
	Sir Musser Clyde De Kol	40368	2	— 674.5	—0.080	— 38.01
	Mean			— 522.5	+0.005	— 17.95
62	Sir Beets Cornucopia Netherland	38460	--	------	------	------
	North Star Longfield Sir Beets	97403	2	+ 317.0	—0.190	— 25.12
63	King Segis of Oak Knoll	49319	--	------	------	------
	Piersma Albina Segis Lad	75361	2	— 867.5	+0.015	— 26.26
64	Sir Piebe Hengerveld De Kol	27929	--	------	------	------
	Sir Piebe Aaggie Hengerveld	32492	5	+ 394.0	—0.214	— 27.46
65	Gem Pietertje Hengerveld Paul De Kol	23300	--	------	------	------
	Sir Hengerveld De Kol Ormsby	31211	2	—1122.0	+0.045	— 32.01
66	Majeppa	2941 F.H.B.	--	------	------	------
	Woodcrest Pietje	35469	2	—1728.5	+0.110	— 38.03
67	Concordia Korndyke Alban	41174	--	------	------	------
	Sir Concordia Korndyke	75012	2	— 770.0	—0.095	— 50.59
68	King Pontiac Champion	53418	14	+4862.1	+0.004	+170.40
	King Champion Victoria	68544	5	+ 288.0	—0.012	+ 8.65
	Pabst Pontiac Champion	105106	2	— 861.0	—0.425	—114.73
	Mean			— 286.5	—0.218	— 53.04
69	De Kol's Pietertje	21033	--	------	------	------
	Earl Korndyke De Kol	24954	2	—1306.0	—0.080	— 56.35
70	Leland Sarcastic	42451	2	—7443.0	+0.060	—209.13
	Missouri Chief Josephine Lad	70857	3	— 27.3	—0.304	— 61.09
71	Friend Hengerveld De Kol Butter Boy	29303	--	------	------	------
	Maplecrest Butter-Boy De Kol	94156	2	— 809.5	—0.225	— 73.48
72	Colantha Johanna Champion	45674	2	+6079.0	—0.015	+221.21
	Johanna De Colantha Champion	60574	13	—1081.9	—0.189	— 74.55
73	Pontiac Aaggie Korndyke	38291	2	— 700.5	+0.465	+ 90.58
	Maple Crest Pontiac Hartog	62178	3	—5624.3	+0.530	— 82.32
74	Sir Cornucopia Prince	48663	6	+3291.0	—0.236	+ 69.26
	Sir College Cornucopia	59755	2	—1904.5	—0.155	— 86.64
75	Mooie Mutual De Kol	32846	--	------	------	------
	Mutual Piebe De Kol	44554	4	— 251.3	—0.427	— 87.82
76	Rag Apple Korndyke	48020	--	------	------	------
	Rag Apple Korndyke De Kol	67211	2	—3831.0	+0.235	— 93.61
77	King Segis Hengerveld	51523	--	------	------	------
	Sir Aaggie Cornucopia Segis	76665	2	—4533.5	+0.260	—109.87
78	Fobes Tritomia Mutual De Kol	40534	--	------	------	------
	Oak De Kol 2d Homestead Fobes	65750	2	—3246.0	—0.060	—114.30
79	Governor Walker	40591	--	------	------	------
	Sir Segis Mutual Walker	80916	2	—3861.0	+0.115	—116.80
80	Sir Johanna Aaggie Posch	38401	5	—1655.2	+0.258	— 10.07
	Sir Johanna Aaggie Posch 4th	72013	2	—2022.0	—0.335	—149.39
81	Virgo Beauty Duke	24528	--	------	------	------
	Alma Prince Jewel	32731	2	—3938.5	—0.110	—152.81
82	Ida Lyons 2d Korndyke	51518	--	------	------	------
	Lakeside Model Alban	71013	2	—3209.5	—0.285	—159.48
83	Oakland Cayuga Chief	27100	--	------	------	------
	Romeo Aaggie Acme of Riverside	32422	2	—9962.5	+0.650	—187.03
84	King Veeman De Kol	36819	--	------	------	------
	Ladoga King Veeman De Kol	43496	2	—3567.5	—0.460	—230.55

Dairy animals, especially bulls, frequently change hands on the basis of what some relative did for milk or butter-fat yield. Only in recent years has the science of genetics furnished any

adequate test of the truth of this saying ("like begets like") for any breeding work and only today are the facts becoming available for dairy cattle. Theoretically sound, perhaps, the dogma demands more for its successful application than ability at the pail or in the Babcock test; it must have an exact measure of the germ cells for their ability to transmit the desired characters. Thus, it is perfectly conceivable in the light of modern genetics that a sire's daughters might be prodigious producers and yet have his sons worthless as transmitters of this production. The data in Table 9 assist in showing the true worth of records either within the immediate ancestry or between close relatives.

There are 84 sires with one or more sons in this list. These sons all have two or more tested daughters from tested dams. The great majority of the sires of these sons do not have two or more daughters from tested dams. Number 12, Juliana King of Riverside, has such records. It will be noted that he decreased the milk yield of his daughters, whereas his son increased it. Both sire and son increased the butter-fat percentage of their daughters considerably. The net result was a considerable increase of the daughters' butter-fat for each sire. In similar fashion, the records of all sires and cows may be compared. Unfortunately, many disappointments will be found in such comparisons.

If the records of sons from the same sires are compared wide differences appear. Thus, the sons of number 17, Sir Homestead Posch De Kol, have a difference in their daughters' butter-fat of nearly 105 pounds. Similar differences appear in the sons of King Segis, Sir Fayne Concordia, Homestead Girl De Kol Sarcastic Lad, etc. In a paper which is to follow this one, these differences will be more adequately discussed in the hope of furnishing some information as to the genotypic value of records of near relatives in advanced registry cattle.

Holstein-Friesian Sires which Materially Advanced the Breed

With the commercial importance of the butter industry the dairyman and breeder of today look to the dairy cow for two things, milk yield and the butter-fat percentage of this milk. With the dairy bull the owner looks for these two variables to be high in the progeny of this bull. Such being the case, it would appear

that the superior sire commercially speaking is the sire which increases the milk yield and butter-fat percentage of his offspring and the inferior sire, the sire which lowers these items. The animals in Tables 4 and 6 have been arranged to show this information. Table 10 gives those sires which increase both the milk yield and butter-fat percentage of their daughters over the production of the dams of these daughters.

TABLE 10.

Holstein-Friesian sires which increased the milk yield and butter-fat percentage of their daughters over that of their dams.

No.	Name of Bull	Registry No.	No. of Pairs	Net Increase		
				In Milk	In Fat %	In Net Fat
1	Johan Woodcrest Lad	52145	3	5140.0	0.413	239.47
2	Emblagaard Tritomia Homestead	62924	5	6716.4	0.024	227.46
3	Alcartra Polkadot Corrector	30624	2	3420.5	0.405	182.21
4	Sir Korndyke Hengerveld De Kol	41266	6	3665.7	0.259	173.00
5	King Pontiac Champion	53418	14	4862.1	0.004	170.40
6	Korndyke Netherland Wayne De Kol	47306	2	2285.5	0.369	150.10
7	Homestead Girl De Kol Sarcastic Lad	32558	4	1995.5	0.338	143.18
8	King Pietertje Cloverdale	69686	3	1817.0	0.354	140.28
9	Greenwood Johanna Lyons	62049	2	2057.0	0.340	137.76
10	Prince Pietertje Beryl	46977	2	1500.0	0.420	137.06
11	Woodcrest Tehee	74219	10	3357.6	0.062	121.63
12	King Segis Hengerveld Vale	60344	5	3176.4	0.044	117.18
13	King Mead of Riverside	50290	6	871.5	0.304	98.08
14	Pietertje Hengerveld Sir Korndyke	60966	5	2040.8	0.116	94.16
15	King of the Pontiacs	39037	3	1789.7	0.113	91.84
16	Sir Korndyke Hengerveld Canary	53825	2	2643.0	0.015	89.43
17	Canary Paul	48328	3	990.0	0.306	85.58
18	Sir Johanna Piebe	53257	10	2338.4	0.009	82.85
19	Gem Pietertje Paul De Kol 3d	44658	5	900.8	0.290	81.37
20	Downing Johanna Burke De Kol	84472	2	1196.0	0.200	73.60
21	Aaggie Cornucopia Pauline Count 13th	44293	4	448.0	0.210	54.47
22	Hartog Paul Burke	49910	3	520.0	0.207	45.63
23	Small Hopes Korndyke De Kol	32260	2	979.5	0.070	43.62
24	Sir Winana Beets Segis	52927	2	79.0	0.220	37.81
25	Johanna Rue 2d's Paul De Kol	21724	4	975.2	0.005	32.37
26	Knight Errant	39566	2	89.5	0.145	30.07
27	Sarcastic Lad	23971	5	289.4	0.012	10.41

Twenty-seven sires have increased the milk yield and butter-fat percentage of their daughters. The leader in increasing the total butter-fat of his daughters is Johan Woodcrest Lad with an average increase of 5140.0 pounds of milk, .413 per cent of butter-fat and 239.47 pounds of butter-fat for his three daughters over the production of their dams.

The sire increasing his daughters' yield least, and yet increasing both of these items, was Sarcastic Lad. Between these two extremes the sires are arranged in accord with the average increase of the butter-fat of their daughters over the butter-fat of the dams of these daughters.

Table 11 shows the sires which decreased their daughters' yield of milk and the percentage of butter-fat contained in this milk.

TABLE 11.

Holstein-Friesian sires which decreased the milk yield and butter-fat percentage of their daughters as compared with that of their dams.

No.	Name of Bull	Registry No.	No. of Pairs	Net Decrease		
				In Milk Lbs.	In Fat %	In Net Fat Lbs.
1	Ladoga King Veeman De Kol	43496	2	3567.5	0.460	230.55
2	Lakeside Model Alban	71013	2	3209.5	0.285	159.48
3	Alma Prince Jewel	32731	2	3908.5	0.110	152.81
4	Pietje 22d Son	58314	2	3467.5	0.135	150.04
5	Sir Johanna Aaggie Posch 4th	72013	2	2022.0	0.335	149.39
6	Sir Korndyke Hengerveld De Kol 36th	85968	3	2975.3	0.087	122.93
7	Pabst Pontiac Champion	105106	2	861.0	0.425	114.73
8	Oak De Kol 2d Homestead Fobes	65750	2	3246.0	0.060	114.39
9	Mutual Piebe De Kol	44554	4	251.3	0.427	87.82
10	Sir College Cornucopia	59755	2	1904.5	0.155	86.64
11	King Pontiac Ruby Burke	58041	2	1728.0	0.125	82.69
12	Johana De Colantha Champion	66574	13	1081.9	0.189	74.55
13	Maplecrest Butter Boy De Kol	94156	2	899.5	0.225	73.48
14	Missouri Chief Josephine Lad	79857	3	27.3	0.304	61.09
15	Sir Johanna Bonheur Fayne	45671	6	383.3	0.220	56.79
16	Earl Korndyke De Kol	24954	2	1396.0	0.080	56.35
17	Sir Concordia Korndyke	75912	2	770.0	0.095	50.59
18	Colantha Johanna Lad	32481	2	279.0	0.140	45.85
19	King Hengerveld Pondyke	47843	6	779.5	0.073	39.09
20	Sir Musser Clyde De Kol	49368	2	674.5	0.080	38.01
21	Aralia De Kol Pontiac Segis	112077	2	369.0	0.030	19.49

Table 11 has the same arrangement as has Table 10. Ladoga King Veeman De Kol decreased the butter-fat of his daughters most, the decrease being 230.35 pounds of butter-fat, 3567.5 pounds for milk yield and 0.460 for butter-fat percentage. The sire which decreased the butter-fat of his daughters least and yet decreased the three items, milk yield, butter-fat percentage and butter-fat was Aralia De Kol Pontiac Segis. Between these two extremes the sires are arranged in accord with the net de-

crease in the butter-fat of their daughters over that of their dams.

Tables 10 and 11, when contrasted, bring out many points of interest concerning the improvement and possibilities of improvement of the Holstein-Friesian breed. There are 27 sires that improve the milk yield and butter-fat percentage of their daughters as compared with 21 which decrease the production of their daughters for these items. Such a ratio of increase to decrease speaks well for the breed providing this ratio may be always maintained or increased. In a previous paper[13] from this laboratory it was shown that within another breed this ratio was 28 to 47, not only was it in the reverse direction but "significantly" so. From this one would conclude that in the present state of development of the two breeds the Holstein-Friesian is not so finely differentiated, e. g. reached so nearly to perfection, as the Jersey. In any case the chance of selecting a good bull capable of transmitting the desired producing qualities to his offspring is nothing about which to boast.

The data of Tables 10 and 11 furnish sires of two sorts, those that improve the milk yield and butter-fat percentages of their daughters and those which decrease these variables. These sires form another group for which pedigree analysis is desirable.

The previous paper[14] in this series has shown the pedigrees of the sires of high milk producing daughters and the pedigrees of the sires of low milk producing daughters to differ but slightly in the ancestors contained in these two groups of pedigrees. Furthermore, study of these groups in comparison with those of a random sample group of sires without advanced registry daughters showed that these sires did not differ "significantly" from either of the advanced registry groups in their ancestors. In the preceding sections of this paper the sires which increased their daughters' milk yield suggestively[15] over that of their dams were compared with the sires that decreased their daughters' milk yield over that of their dams, suggestively. These groups were found to correspond surprisingly in their ancestors, having

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[13]loc. cit.

[14]Gowen, John W. and Covell, Mildred R. Studies in Milk Secretion. IX On the Performance of the Progeny of Holstein-Friesian Sires.

[15]Suggestively is used to mean 2 x the probable error.

many in common. Similar results were obtained for the pedigrees of the groups increasing or decreasing their daughters' butter-fat percentage over that of their dams. These results appear to justify the conclusion that the ancestors appearing in the pedigree of a sire in the third or fourth generation by no means predict what the sire's worth may be as a getter of either high milk yielding or butter-fat percentage progeny, or of increasing the milk yield or butter-fat percentage of his daughters over that of their dams. It now remains to be shown if the group of sires increasing both milk yield and butter-fat percentage differ in their ancestry from those which decrease both of these variables.

Ancestral Analysis of Sires with Superior and Inferior Transmitting Powers for Milk Production, Butter-Fat Percentage and Butter-Fat

The pedigree analysis of the sires contained in Table 10 for the inbreeding and relationship which exists in each pedigree is given in Table 12. The inbreeding constants for the second, third, and fourth generation are represented as Z_1, Z_2 and Z_3. The total inbreeding is represented by Z_{T_3}. The kinship for each generation is indicated by K_2, K_3 and K_4.

Even casual inspection of Table 12 shows that the inbreeding is small in amount. No inbreeding exists in the second generation of any of the pedigrees. In the third generation 2 sires show some inbreeding. The fourth generation has 15 sires which show some inbreeding. The total amount of inbreeding is relatively slight for each generation, amounting to an average per sire for the whole table of .9 per cent for the third and 4.7 per cent for the fourth generation. In terms of its total possible amount this group of sires has only 2.5 per cent of the inbreeding possible under the brother and sister system of mating.

Only one sire shows relationship between his sire and dam in the third generation. Six show some relationship in the fourth generation. The amount of this relationship is .9 per cent for the third generation and 4.6 per cent for the fourth generation.

If these amounts of inbreeding are compared with their probable error as calculated from the standard deviations of each constant, it is found that the average inbreeding does not differ significantly from zero.

TABLE 12.

Inbreeding and relationship shown in the pedigrees of the Holstein-Friesian sires which increased the milk yield and butter-fat percentage of their offspring.

No.	Name	Reg. No.	Z	Z_2	Z_3	ZT_3	K_2	K_3	K_4
1	Johan Woodcrest Lad	52145	0	0	0	0	0	0	0
2	Emblagaard Tritomia Homestead	62924	0	0	0	0	0	0	0
3	Alcartra Polkadot Corrector	30624	0	0	0	0	0	0	0
4	Sir Korndyke Hengerveld De Kol	41266	0	0	12.5	5.9	0	0	25.0
5	King Pontiac Champion	53418	0	0	0	0	0	0	0
6	Korndyke Netherland Wayne De Kol	47306	0	0	6.3	3.0	0	0	12.5
7	Homestead Girl De Kol Sarcastic Lad	32558	0	0	0	0	0	0	0
8	King Pietertje Cloverdale	69686	0	0	0	0	0	0	0
9	Greenwood Johanna Lyons	62049	0	0	6.3	3.0	0	0	0
10	Prince Pietertje Beryl	46977	0	0	6.3	3.0	0	0	12.5
11	Woodcrest Tehee	74219	0	12.5	12.5	10.0	0	25.0	25.0
12	King Segis Hengerveld Vale	60344	0	0	6.3	3.0	0	0	12.5
13	King Mead of Riverside	59290	0	0	0	0	0	0	0
14	Pietertje Hengerveld Sir Korndyke	60966	0	0	12.5	5.9	0	0	12.5
15	King of the Pontiacs	39037	0	0	0	0	0	0	0
16	Sir Korndyke Hengerveld Canary	53825	0	0	0	0	0	0	0
17	Canary Paul	48328	0	0	6.3	3.0	0	0	0
18	Sir Johanna Piebe	53257	0	0	12.5	5.9	0	0	12.5
19	Gem Pietertje Paul De Kol 3rd	44658	0	0	0	0	0	0	0
20	Downing Johanna Burke De Kol	84472	0	0	0	0	0	0	0
21	Aaggie Cornucopia Pauline Count 13th	44293	0	0	6.3	3.0	0	0	0
22	Hartog Paul Burke	49910	0	0	6.3	3.0	0	0	0
23	Small Hopes Korndyke De Kol	32260	0	12.5	12.5	10.0	0	0	0
24	Sir Winana Beets Segis	52927	0	0	6.3	3.0	0	0	12.5
25	Johanna Rue 2d's Paul De Kol	21724	0	0	0	0	0	0	0
26	Knight Errant	39566	0	0	6.3	3.0	0	0	0
27	Sarcastic Lad	23971	0	0	6.3	3.0	0	0	0
	Average		0	.9	4.7	2.5	0	.9	4.6

Table 13 gives the inbreeding and relationship shown by the sires which decrease the milk yield, butter-fat percentage and butter-fat of their offspring.

The inbreeding shown by the pedigrees of the sires whose daughters are lower producers than their dams is slightly more than that of the sires whose daughters are greater producers than their dams. Compared with its probable error, however, this difference is not significant. Furthermore, the inbreeding shown by this group of sires of Table 13 is not significantly different from zero inbreeding. Such being the case, it cannot be argued that inbreeding has any appreciable effect on the milk yield or butter-fat percentage of the progeny, at least, as this inbreeding

TABLE 13.

Inbreeding and Relationship shown in the pedigrees of the Holstein-Friesian sires which decreased the milk yield and butter-fat percentage of their offspring.

No.	Name	Reg. No.	Z_1	Z_2	Z_3	Z_{T3}	K_2	K_3	K_4
1	Ladoga King Veeman De Kol	43496	0	0	6.3	3.0	0	0	0
2	Lakeside Model Alban	71013	0	12.5	12.5	10.0	0	0	0
3	Alma Prince Jewel	32731	0	0	6.3	3.0	0	0	0
4	Pietje 22d Son	58314	0	0	0	0	0	0	0
5	Sir Johanna Aaggie Posch 4th	72013	0	0	0	0	0	0	0
6	Sir Korndyke Hengerveld De Kol 36th	85968	0	0	0	0	0	0	0
7	Pabst Pontiac Champion	105106	0	0	0	0	0	0	0
8	Oak De Kol 2d Homestead Fobes	65750	0	0	6.2	3.0	0	0	12.5
9	Mutual Piebe De Kol	44554	0	0	12.5	10.0	0	0	12.5
10	Sir College Cornucopia	59755	0	0	6.3	3.0	0	0	12.5
11	King Pontiac Ruby Burke	58941	0	0	6.3	3.0	0	0	12.5
12	Johanna De Colantha Champion	60574	0	12.5	25.0	17.7	0	25.0	37.5
13	Maplecrest Butter Boy De Kol	94156	0	0	6.3	3.0	0	0	0
14	Missouri Chief Josephine Lad	70857	0	0	0	0	0	0	0
15	Sir Johanna Bonheur Fayne	45671	0	0	6.3	3.0	0	0	0
16	Earl Korndyke De Kol	24954	0	0	0	0	0	0	0
17	Sir Concordia Korndyke	75912	0	0	6.3	3.0	0	0	12.5
18	Colantha Johanna Lad	32481	0	0	6.3	3.0	0	0	0
19	King Hengerveld Pondyke	47843	0	0	0	0	0	0	0
20	Sir Musser Clyde De Kol	40368	0	12.5	12.5	10.0	0	0	0
21	Aralia De Kol Pontiac Segis	112077	0	0	12.5	5.9	0	0	0
	Average		0	1.8	6.3	3.8	0	1.2	4.8

is normally carried on in the Holstein-Friesian breed. This conclusion agrees with that shown by the preceding pages of this paper and also with that of the previous paper of this series on the progeny performance of Holstein-Friesian sires for year milk yields, butter-fat percentage, and butter-fat. Such being the case, it seems entirely justifiable to generalize this conclusion for the advanced registry of this breed; namely, that inbreeding of Holstein-Friesian sires as normally practiced in the breed has no detrimental effect on the milk production of the sire's female offspring.

Comparison of the results of Table 13 with those of Table 12 on the kinship of the sires of daughters of high produciton with those of low production as compared with the production of the dams of these daughters show that the kinship is practically the same. Furthermore, the kinship is so small in average amount that it is "not significantly" different from zero, when the probable errors are considered. This agrees with the results as given

earlier in this paper and also for the results as given for the progeny performance of Holstein-Fiesian sires. This agreement leads to the conclusion that as normally carried on in the Holstein-Friesian breed the inbreeding and relationship shown by a sire have little or no effect on the production of his offspring. Not only does this conclusion hold for the Holstein-Friesian breed but it also has been shown to hold for the Jersey breed.

A favorite pastime is the pedigree study of the best sires in a breed to determine the families from whence these sires came. Always it is the best, seldom or never do poor sires, become included in such a study and yet how obviously futile is such a study without a comparison of the ancestors of the best with the ancestors of the worst. In two preceding papers within this series and in the foregoing pages of this paper these comparisons have been made for certain groups of sires separated from one another by wide differences in milk yield or butter-fat percentage. The two tables 10 and 11 furnish another group for which such a comparison is of value as a contribution toward the solution of which ancestors transmitted the high or the low milk yield or butter-fat percentage to their offspring.

Before beginning this study it was decided that any individual which was not repeated at least once in the pedigrees of a given group of sires could not have contributed any noticeable amount to making the group as a whole worthy or unworthy. Accordingly, the study will confine itself to those animals that were repeated at least once.

Table 14 gives the animals repeated in the pedigrees of the sires which increased the milk production and butter-fat percentage of their daughters over that of their dams.

TABLE 14.

Animals repeated in pedigrees of sires which increased the milk production and butter-fat percentage of their daughters as compared with that of their dams.

1st Generation Sire's Side Males	Herd Book No.	No. of Appearances	1st Generation Dam's Side Females	Herd Book No.	No. of Appearances
Homestead Girl DeKol			Females appearing once for which only herd book number need be given. 23039, 33788, 44130, 48423, 49131, 51585, 65765		
Sarcastic Lad	32558	2			
King Segis	36168	2			
Males appearing once for which only herd book number need be given. 18726, 22128, 22394, 23102, 25982, 26025, 26766, 26935, 28400, 39037, 41266					
2nd Generation Males			2nd Generation Males		
DeKol 2d's Paul DeKol	20735	2	Paul Beets DeKol	22235	3
Pauline Paul 2d's Count	22909	2	Hengerveld DeKol	23102	2
Johanna Aaggie's Sarcastic Lad	26935	2	Pietertje Heng.'s Count DeKol	23224	2
Mercedes Julips Pietj.'s Paul	29830	2			
Males appearing once for which only herd book number need be given. 14634, 17638, 21366, 22779, 23102, 23109, 23300, 23366, 23971, 24762, 25368, 25982, 26766, 28133			Males appearing once for which only herd book number need be given. 4729, 6296, 11822, 17064, 19856, 20735, 25700, 25982		
2nd Generation Females			2nd Generation Females		
Homestead Girl DeKol	48423	3	Females appearing once for which only herd book number need be given. 4553, 12586, 16275, 21223, 28772, 34745, 40182		
Belle Korndyke	13913	2			
A. & G. Inka McKinley	55163	2			
Females appearing once for which only herd book number need be given. 10513, 11227, 24137, 29237, 32406, 36477, 39947, 41934, 46490, 48426, 51585, 52256, 65765					
3rd Generation Males			3rd Generation Males		
DeKol 2d's Paul DeKol	20735	7	DeKol 2d's Butter Boy	21366	4
Paul DeKol	14634	3	DeKol 2d's Paul DeKol	20735	3
Milla's Pietertje Netherland	7825	2	Paul DeKol	14634	2
Silvan Hartog	8161	2	Sarcastic Lad	23971	2
Count Paul DeKol	19108	2			
Manor DeKol	21226	2			
Johanna Rue 2d's Paul DeKol	21724	2			
Pietj. Heng's Paul DeKol	22128	2			
Billy McKinley	23378	2			
Sarcastic Lad	23971	2			

3rd Generation Females			3rd Generation Females		
DeKol 2d	734	3	DeKol 2d	734	3
Homestead Girl	16275	3	Jessie Beets	8123	3
Kate Korndyke	23SD.F.H.B.	2	Pietertje Hengerveld	24137	2
Netherland Hengerveld	13106	2	Magadora	29237	2
Belle Korndyke	13913	2			
Pauline Paul 2d	31477	2			
May Hartog of Brookside	36420	2			
Johanna Aaggie	36477	2			
Segis Inka	36617	2			
Mercedes Julip's Pietertje	39480	2			

4th Generation Males			4th Generation Males		
Paul DeKol	14634	9	Milla's Pietertje Netherland	7825	5
DeKol 2d's Netherland	11584	4	Paul DeKol	14634	4
Willem III	190N.H.B.	3	Sir Abbekerk	19056	4
DeKol 2d's Prince	2767	3	Willem III	190H.H.B.	3
Sir Henry Beatus	3337	3	Mooie Hartog 4th	418D.F.H.B.	3
Aaggie Cornelia 5th's Clothilde Imperial	11822	3	DeKol 2d's Prince	2767	2
Paul Mutual DeKol	18726	3	Inka Princess Pietj. Netherland	3979	2
DeKol 2d's Butter Boy	21366	3	Paul Mutual DeKol	18726	2
Paul Hartog	6M.R.	2	Aaltje Salo 3d's Tritomia Netherland	19856	2
Prince of Monroe	163OH.H.B.	2	Maurice Bonheur	22394	2
Netherland Statesman	328OH.H.B.	2			
Aaggie Leila's Prince	4419H.H.B.	2			
Duke Netherland	1271	2			
Silvan Hartog	8161	2			
Inka Princess' Pietj. Netherland	13979	2			
Kate H.'s Hartog	14881	2			
Tritomia's Netherland Carl	16406	2			
DeKol 2d's Paul DeKol	20735	2			
Elaine's Pietertje	20854	2			
Manor DeKol	21226	2			
Aaggie Beauty 2d's Hero	21490	2			
Maurice Bonheur	22394	2			

4th Generation Females			4th Generation Females		
DeKol 2d	734	10	DeKol 2d	734	7
Pauline Paul	2199H.H.B.	5	Netherland Hengerveld	13106	5
DeKol	6245H.H.B.	3	Dora Beets 3d	26SD.F.H.B.	3
Napoli	7159H.H.B.	3	DeKol	6245H.H.B.	3
Netherland Hengerveld	13106	3	Pauline Paul	2199H.H.B.	2
Pietertje Hengerveld	24137	3	Helena Burke	22916	2
Johanna Rue 2d	33788	3	Belle Sarcastic	23039	2
3d Maartje Korndyke	17M.R.	2			
Kate Korndyke	23SD.F.H.B.	2			
Lutske 2d	267D.F.H.B.	2			
Segis	5765H.H.B.	2			
Milla	640SH.H.B.	2			
Madame Hengerveld	1333	2			
DeKol 2d's Queen	6324	2			
May Hartog	9702	2			
Belle Korndyke	13913	2			
Pleasant Valley Maid's Pietertje	18314	2			
Belle Sarcastic	23039	2			
Mercedes Julip	33403	2			

An outstanding feature of this table is noticeable on inspection. The number of individuals repeated on the dam's side of the pedigree is only a fraction of those repeated on the sire's side of the pedigree. Since the popularity of an animal is based on what is conceived to be his worth, it follows from the above

that the animals considered to be worth most are included in the sire's side of the pedigree more often than they are included in the dam's side of the pedigree. Such a selection would seem to mean that the sires are more carefully chosen than the dams to which they are bred. This would probably follow from the obvious difference in the reproductive capacities of a bull and a cow, allowing, as it does, more freedom of choice for the bull than for the cow.

Animals occurring in the first generation of any pedigree do not have the same chance to repeat as do the animals in the second generation, due to the fact that the actual number of animals in the first generation is only half that in the second generation. Likewise, the animals in the second generation do not have the same chance to repeat as do the animals in genertions further removed. It is consequently more to the credit of any animal to be repeated once in the first generation than to be repeated once in subsequent generations. This point should be kept in mind in viewing the evidence presented in the table.

The total number of appearances which a given ancestor has in the pedigree group is, for comparative purposes, perhaps the best measure of the relative worth of that animal in other pedigrees. Such a measure favors the third and fourth generation animals. The conclusions drawn from it should consequently be considered as referring largely to these generations. The frequency of appearance of the animals repeated three or more times is given below. The animals are arranged in order of their number of appearances, the sire's side of the pedigree being given first followed by the dam's side. The bulls are Paul De Kol (13-6), De Kol 2d's Paul De Kol (11-4), De Kol 2d's Butter Boy (5-4), Milla's Pietertje Netherland (3-5), Sir Abbekerk (2-5), Paul Mutual De Kol (4-2), Maurice Bonheur (4-2), Sarcastic Lad (3-3), Willem III (3-3), Aaggie Cornelia 5th's Clothilde Imperial (4-2), De Kol 2d's Prince (4-2), Aaltje Salo 3d's Tritomia Netherland (2-3), Silvan Hartog (4-1), De Kol 2d's Netherland (4-1). Hengerveld De Kol (3-2), Manor De Kol (4-1), Pontiac Korndyke (3-1), Pietj. Heng.'s Paul De Kol (3-1), Tritomia's Netherland Carl (2-2), Sir Henry Beatus (3-1), Inka Princess' Pietj Netherland (2-2), Manor Josephine De Kol (3-1), Johanna Aaggie's Sarcastic Lad (3-0), Homestead Jr. De Kol (3-0), Empress Josephine 3d's Sir Mechthilde

(2-1), Johanna Rue 2d's Paul De Kol (2-1), Pietertje Heng's Count De Kol (1-2), De Kol 2d's Alban (1-2), Paul Beets De Kol (0-3), Mooie Hartog 4th (0-3), Clothilde 4th's Imperial (1-2).

The cows appearing 3 or more times are De Kol 2d (13-10), Netherland Hengerveld (5-5), Pauline Paul (6-2), Belle Korndyke (6-2), Pietertje Hengerveld (4-2), Belle Sarcastic (3-3), De Kol (3-3), Johanna Rue 2d (4-1), Kate Korndyke (4-1), Magadora (3-2), Homestead Girl De Kol (3-1), Homestead Girl (3-1), Napoli (3-1), Johanna Rue (1-2), Helena Burke (1-2), Jessie Beets (0-3), Dora Beets 3d (0-3), Maplecroft Gem (2-1), Agnes De Kol's Ellen (2-1), Johanna Aaggie (3-0).

It is generally considered that the relative frequency of appearances of these animals indicates the animal's merit as a transmitter of milk production and butter-fat percentage. Past experience in the pedigree studies of this laboratory indicate that such is by no means always the case for animals in the superior group may often be repeated in the poor group and in comparable numbers. The ancestral analysis of the sires of the inferior group, those which decreased the milk yield and butter-fat percentage of their daughters over that of their dams, is given in Table 15.

TABLE 15.

Animals repeated in pedigrees of sires which decreased the milk production and butter-fat percentage of their daughters as compared with the milk production and butter-fat percentage of their dams.

1st Generation Sire's Side Males	Herd Book No.	No. of Appearances	1st Generation Dam's Side Females	Herd Book No.	No. of Appearances
King of the Pontiacs	39037	2	Females appearing once for which only herd book number is needed.		
Males appearing once for which only herd book number need be given.			13913. 48577		
23971, 32558, 32846, 35227, 41266					

2nd Generation Males			2nd Generation Males		
Pontiac Korndyke	25282	2	Homestead Jr. DeKol	28400	2
Males appearing once for which only herd book number need be given. 14634, 22394, 23102, 23269, 23971, 25700, 26935, 28400, 31789, 32846, 35227, 39037			Males appearing once for which only herd book number is needed. 8161, 17064, 22991, 23446, 23447, 23538, 31789		
2nd Generation Females			2nd Generation Females		
Pontiac Lunde Hengerveld	51585	2	Females appearing once for which only herd book number is needed. 238 (D.F.H.B.), 35028		
Females appearing once for which only herd book number need be given. 23039, 37486, 44124, 44130, 48423, 48577, 65765					
3rd Generation Males			3rd Generation Males		
Pontiac Korndyke	25982	3	Netherland Alban	4584H.H.B.	2
Aaltje Salo 3d's Tritomia Netherland	19856	2	Aaggie Cornelia 5th's Clothilde Imperial	11822	2
Mutual Friend 3d's Paul	23200	2	Hollander 2d's Sir Henry	14681	2
Sarcastic Lad	23971	2	Paul DeKol Jr.	24762	2
Paul DeKol Jr.	24762	2			
DeKol 2d's Mutual Paul	25700	2			
Manor Josephine DeKol	22779	2			
Hengerveld DeKol	23102	2			
3rd Generation Females			3rd Generation Females		
DeKol 2d	734	2	Homestead Heroine DeKol	46490	2
Belle Korndyke	13913	2			
Johanna Aaggie	36477	2			
Pontiac Lunde Hengerveld	51585	2			
Lunde Beauty	34745	2			
4th Generation Males			4th Generation Males		
Paul DeKol	14634	5	Paul DeKol	14634	3
Aaggie Cornelia 5th's Clothilde Imperial	11822	3	DeKol 2d's Paul DeKol	20735	3
Manor Josephine DeKol	22779	3	Pietj. Heng.'s Paul DeKol	22128	3
DeKol 2d's Butter Boy	21366	3	Clothilde 4th's Imperial	1281	3
Willem III	190N.H.B.	2	Netherland Prince	716H.H.B.	3
Hamilton	628D.F.H.B.	2	Sir Henry of Maplewood	2933H.H.B.	2
Milla's Pietertje Netherland	7825	2	Bassano	3917H.H.B.	2
Silvan Hartog	8161	2	Mechthilde's Sir Henry of Maplewood	6296	2
DeKol 2d's Netherland	11584	2	Aaggie Cornelia 5th's Clothilde Imperial	11822	2
Prince of Ninety	15243	2	Aaltje Salo 3d's Tritomia Netherland	19856	2
Tritomia's Netherland Carl	16406	2	DeKol 2d's Butter Boy	21366	2
Aaltje Salo 3d's Tritomia Netherland	19856	2	Romeo Aaggie	21970	2
Empress Josephine 3d's Sir Mechthilde	20258	2	DeKol Burke	22991	2
Maurice Bonheur	22394	2			
Hengerveld DeKol	23102	2			
Mutual Friend 3d's Paul	23200	2			

4th Generation Females			4th Generation Females		
DeKol 2d	734	6	Albino	2654H.H.B.	2
Belle Korndyke	13913	3	Hollander 2d	5782H.H.B.	2
Kate Korndyke	238D.F.H.B.	2	Aaggie Cornelia 5th	6733H.H.B.	2
DeKol	6245H.H.B.	2	Duchess Ormsby	16004	2
Pleasant Valley Maid	9431H.H.B.	2	Johanna Rue	21223	2
Johanna 4th	2129	2	Sadie Vale Concordia	32259	2
Aaltje Salo 3d	7403	2	Heroine DeKol	41387	2
Netherland Hengerveld	13106	2			
Belle Sarcastic	23039	2			
Lunde 3d's Perfection	27881	2			
Pietertje Hengerveld	24137	2			
Magadora	29237	2			
Mutual Friend 3d	28389	2			
Agnes DeKol's Ellen	30228	2			
Sadie Vale Concordia	32259	2			
Lunde Beauty	34745	2			
Korndyke Queen DeKol	41934	2			

Examination of Table 15 in comparison with Table 14 shows that many of the same animals occurring in the pedigrees of the sires which increase their daughters' production also occur in the pedigrees of the sires which decrease their daughters' production. The names of the animals which appear in the pedigrees of the sires of low producing daughters more than three times are given below. Certain of the names are in *italics*. These animals also have at least three appearances in the pedigrees of the sires which increased their daughters' milk yield and butterfat percentage. The bulls which appear three or more times are *Paul De Kol* (7-3), *Pontiac Korndyke* (6-1), *Aaggie Cornelia 5th's Clothilde Imperial* (3-4), *Sarcastic Lad* (5-2), *De Kol 2d's Butter Boy* (4-3), *Manor Josephine De Kol* (5-1), *Hengerveld De Kol* (5-1), *Aaltje Salo 3d's Tritomia Netherland* (4-2), *Maurice Bonheur* (4-1), *De Kol 2d's Paul De Kol* (2-3), De Kol Burke (1-4), Paul De Kol Jr. (3-2), *Homestead Jr. De Kol* (2-2), *Pietj. Hengerveld's Paul De Kol* (1-3), *De Kol 2d's Netherland* (3-1), *Milla's Pietertje Netherland* (3-1), Mutual Friend 3d's Paul (4-0), *Clothilde 4th's Imperial* (0-3), *Tritomia's Netherland Carl* (2-1), *Silvan Hartog* (2-1), *Willem III* (2-1), Piebe De Kol Burke (1-2), Netherland Alban (1-2), King of the Pontiacs (3-0), Netherland Prince (0-3), Sir De Kol Mechthilde (1-2), De Kol 2d's Mutual Paul (3-0).

The cows which appear three or more times are *De Kol 2d* (8-2), *Belle Korndyke* (5-2), *Belle Sarcastic* (4-1), Sadie Vale Concordia (3-2), Lunde Beauty (4-0), Colantha 4th (1-3), Homestead Heroine De Kol (2-2), Pontiac Lunde Hengerveld

(4-0), *De Kol* (2-1), *Johanna Aaggie* (3-0), Colantha (1-2), Heroine De Kol (1-2), *Kate Korndyke* (2-1), *Magadora* (3-0).

The animals in these lists are arranged in order of the number of times which they appear in the two pedigree lists. The names in italics in the above group of animals make it clear that most of the sires whose progeny test shows them superior, have ancestors in common with the sires whose progeny test show them inferior. Further if the lists are examined in conjunction with the complete list of animals which appear in each pedigree group, it is found that there are only 3 bulls and 3 cows appearing in the increase pedigrees which do not appear in the decrease group. Similarly, if the decrease group is compared with the complete list of animals appearing in the increase pedigrees, it is found that no bulls and only one cow have no appearances in the increase group. In view of these facts can any stronger proof be needed of the futility of studying the best pedigree with the express purpose of drawing general conclusions from such a study as to the best families within a breed?

The relative frequency of appearance of these different bulls and cows in one group is seen to be striking similar to that in the other. This is brought out more clearly by a comparison of the constants to determine the relationship between the number of appearances in one pedigree and the number of appearances in the other pedigree group. The relationship constants, as correlation coefficients, are given in Table 16 for the increase group of Table 14, the decrease group of Table 15 and the random sample group of pedigrees in Table 9 of the paper on the progeny performance test of Holstein-Friesian sires. It will be remembered that these random sample sires had no advanced registry daughters and were selected at random from the general Holstein-Friesian breed.

Likewise, the pedigrees of the sires which increased their daughters' milk yield and butter-fat percentage are very similar to the pedigrees of sires without any advanced registry daughters. The lowest relationship exists between the pedigrees of the sires which decrease the milk yield and butter-fat percentage of their daughters and those of the sires which had no advanced registry daughters. The relationship is distinctly significant, however. The comparison of the pedigrees of the increase group with the random sample group and the decrease group with the random

sample group show that the increase group has ancestors significantly more like those of the random sample group of sires without advanced registry daughters than the decrease group has like the random sample group.

TABLE 16.

Correlation coefficients for the frequency of appearance of bulls and cows within the pedigrees of the sires of the three following groups, (1) sires whose daughters were better than their dams in milk yield and butter-fat percentage (Increase group) (2) sires whose daughters were lower than their dams in milk yield and butter-fat percentage (Decrease group), (3) sires of random sample group without advanced registry offspring.

Characters Correlated	Males	Females
Increase group and Decrease group	0.73±.02	.70±.03
Increase group and Random Sample group	.52±.04	.49±.04
Decrease group and Random Sample group	.37±.04	.34±.05

Table 16 shows clearly that the pedigrees of the sires which increased their daughters' milk yield and butter-fat percentage are very closely similar to the pedigrees of the sires which decreased their daughters' milk yield and butter-fat percentage.

These data bear on the final point of this paper. It has been shown in these two papers on the 365 day test of the Holstein-Friesian breed, the one on the progeny performance test and the other on the daughter-dam test that the pedigrees of sires in the following contrasted groups contain nearly the same animals and in relatively the same proportions.

(1) Sires of high milk producing daughters vs. sires of low milk producing daughters.

(2) Sires of high butter-fat percentage daughters vs. sires of low butter-fat percentage daughters.

(3) Sires of daughters which were higher in their milk yield and butter-fat percentage than the dams from which they sprang vs. the sires of daughters which were lower in their milk yield and butter-fat percentage than their dams.

(4) Sires without any advanced registry daughters taken at random from the herd book vs. any of the above groups.

In view of this evidence, can there be ground for the belief that the presence of a famous animal in a pedigree represents the true worth of the unknown bull pedigreed? Can it be assumed that the fact that certain famous sires trace back to certain groups of animals or families, in and of itself makes these families worthy? Should the answer be negative to either of these questions the conclusion naturally follows that, as normally carried on, pedigree study has little real significance.

Conclusions

The objective of this paper is the presentation of a "Progeny Performance" analysis of the sires of the Holstein-Friesian advanced register with year test daughters, to ascertain the nature of their transmitting qualities for milk production, butter-fat percentage and butter-fat. Before applying this test it was necessary to correct the milk records to a standard age. The standard age chosen was eight years.

The quartile limits for the corrected milk production and butter-fat percentage were determined both for the daughters and for the dams that composed the daughter-dam pairs. These quartile limits are shown in Table 2. This information showed the daughter's milk production to be the same as the dam's milk production within the limits of random sampling, the daughter's butter-fat percentage to be lower than the dam's by a slightly significant amount.

The probable errors of the sire's transmitting qualities (Daughter's performance—Dam's performance) are derived from the standard deviations of the corrected milk production and butter-fat percentage. These probable errors are shown in Table 3.

The quartile lines divide the population into four equal parts. These parts are designated A the highest, B the next highest, C the next lower and D the lowest. The relative milk production or butter-fat percentage of each daughter-dam pair has been determined in this manner. The position of the dam is placed first and the position of the daughter second. Thus a record AB for milk production states that the dam's milk production was above

21392 pounds, and the daughter's milk production between 19246 and 22289 pounds.

There are 111 Holstein-Friesian sires, having two or more year test daughters in the advanced registry from tested dams, which meet the requirements of this performance test for transmitting qualities of milk yield. Sixty-five of these sires or slightly more than one-half raised the milk yield of their daughters over that of the dams of these daughters. The leader in raising his daughters' milk yield was Ormsby Korndyke Lad. The increase in this case amounted to 7637.5 pounds. This sire had two daughters, both in the A class. One of these daughters came from an A class dam, the other came from a D class dam. Of the sires with a good number of daughters King Pontiac Champion made the best showing. This sire had 14 daughters from all kinds of dams, low to high producing. He raised his daughters' average production by 4862.1 pounds over the production of their dams.

Two groups of the sires in Table 4 were selected for purposes of comparison, those which increased their daughters' milk yield two times its probable error and those which decreased their daughters' milk yield a similar amount. Eleven sires were in the first group and three sires were in the second group. No significant difference in inbreeding or relationship was found to exist between these two groups. The leading animals appearing in pedigrees of each group were the same.

One hundred and eleven sires have their transmitting powers tested for butter-fat percentage in Table 6. Out of this number 32, or slightly less than half, raise their daughters' average butter-fat percentage over that of their dams. The leader, in increasing the butter-fat yield of his daughters, was Kalmuck Skylark Johanna. This bull had two daughters from C class dams. Both of these daughters were raised to the A class in their butter-fat percentage. Relatively few sires with a considerable number of daughters appear in the bulls which increase their daughters' butter-fat percentage to any degree. Thus, Woodcrest Tehee, the first sire with 10 or more daughter-dam pairs, is 40th in the list of 111 sires.

Two groups of sires in Table 6 were selected to determine the effect of inbreeding and relationship on the butter-fat percentage of their daughters. The first group contained sires which

raised their daughters' butter-fat percentage 2 times the probable error more than their dams. The second group was selected to contain those sires whose daughters were 2 times the probable error below their dams in butter-fat percentage. While the inbreeding and relationship of the sires which raised their daughters' butter-fat percentage is lower than for the sires which lowered their daughters' butter-fat percentage, the differences between them is not significant. The leading animals appearing in each pedigree group were found to be the same.

There are 111 sires with known transmitting qualities for butter-fat percentage given in Table 8. Seventy-one of these sires increase the butter-fat percentage of their daughters over the butter-fat percentage of their dams. The leader in increasing the butter-fat of his daughters was Ormsby Korndyke Lad. Of those bulls with a fair number of daughters King Pontiac Champion and Woodcrest Tehee increased their daughters' butter-fat to the greatest amount.

The information summarized above was arranged in Table 9 to reveal the transmitting qualities for milk production, butter-fat percentage and butter-fat of Holstein-Friesian sires to their sons. Eighty-four sires had one or more sons with known transmitting ability. Very few of these sires had their own transmitting ability known. King Korndyke Hengerveld Ormsby's son, Ormsby Korndyke Lad, was the leader. King Korndyke Hengerveld Ormsby's own daughter-dam test was not known. Of the sires with two or more sons, Hengerveld De Kol's sons increased their daughters to the largest amount of butter-fat.

This table shows that the sons of a sire may differ from their father in their transmitting ability by large amounts. The cows may also differ from each other by wide differences.

The sires of superior merit are defined as those which raise the milk production and butter-fat percentage of their daughters as compared with that of their dams. The inferior sires are defined as those sires that lower the milk production and butter-fat percentage of their daughters as compared with the same variables in their dams. The superior sires so defined are arranged in Table 10 by the amount of butter-fat that they increase the production of their daughters over that of their dams. The inferior sires are classified in Table 11 according to the amount of

butter-fat that they decrease the production of their daughters in comparison with that of their dams.

These two groups of sires are subjected to four generation pedigree analysis to determine their inbreeding and relationship, and the individual animals most frequently repeated into two groups of pedigrees. There are 27 sires in the group of sires superior in their transmitting qualities for milk production and butter-fat percentage. In the group of sires inferior in their transmitting ability for these two characters there are 21 sires. The two groups of sires differ but slightly in numbers or in their range of butter-fat. The inbreeding coefficients show that the sires of superior merit have 3.5 per cent of the greatest possible inbreeding up to the fifth generation. The inferior sires are inbred 3.8 per cent of the greatest possible amount (continued brother and sister mating).

The difference in the inbreeding of the two groups is slight. The total amount of inbreeding is also very low in either group. Such a result indicates that as normally carried on inbreeding in the sire's pedigree has no detrimental effect on the production of his offspring.

The analysis of the pedigrees for the amount of relationship that may exist between the sire and dam of the individual bulls in the superior group and in the inferior group shows that there is little or no difference in the amount of this relationship within the two groups.

These two groups of pedigrees have been analyzed for the frequency of appearance of the individual animals which they contain. The group of superior sires is then compared with the group of inferior sires and also with a random sample of sires without advanced registry daughters. Comparison of the three groups show that they have ancestors closely similar to each other. These ancestors occur in about the same proportion in each group. In view of this evidence, it seems very doubtful indeed if there is adequate ground for the belief that the presence of a famous animal in a pedigree represents the true worth of the unknown bull pedigreed. Such being the case it naturally follows that as normally carried on pedigree study has little real meaning, at least further back than the second generation.